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PROCEEDINGS

Longleaf Pine Workshop

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Mobile, Alabama

October 17~19, 1978

U. S. Department of Agriculture • Forest Service • Southeastern Area • State and Private Forestry
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FOREWORD

Longleaf pine, long recognized for its quality, has shrunk from a major southern species to the point that it almost gone from the consciousness of the practicing forester and management oriented landowner. Problems in regeneration both real and perceived, have discouraged foresters and landowners alike. Yield information for managed stands, natural and artificial, was incomplete,raising economic questions regarding the use of longleaf. Fortunately, there were people with interest and faith in longleaf pine as a southern pine species with a future.

Knowledge developed from research findings and practical experience has shown that longleaf pine can be successfully regenerated and managed. Concurrently a reawakened interest in matching species to site has taken place. As experience accumulates we have become more aware of the need for recognizing the need to put each species where it performs best. Researchers and practicing foresters alike felt the time had come to bring the available information together for review and discussion. With these thoughts in mind, this workshop was heavily weighted to open discussion and field trips.

We want to acknowledge the contribution the panel moderators made to the workshop. They set the stage for each panel and kept the program on schedule, all while maintaining the dialogue between panel members and the participants. A difficult job that was well done. The moderators were: C. W. Moody, State Forester of Alabama; Robert G. Hitt, Staff Director, Southeastern Area, State and Private Forestry; and Robert P. Schultz, Asst. Director, Southern Forest Experiment Station.

The program committee also deserves much credit for the success of the workshop. In addition to serving on the program committee, Charles Baucom did a superb job making all the local arrangements, Bill Boyer and Tom Croker made the arrangements for the field trip to the Escambia Experimental Forest, and Calvin Bey with Bayne Snyder's assistance arranged the Harrison Experimental Forest field trip.

Our thanks also go to the local sponsors who contributed much to the success of the program.

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WELCOME

C. W. MOODY [1]

I was talking to Ed Leigh McMillan the other day and asked him why they plant longleaf pine. I felt his answer would be significant since the McMillans and T. R. Miller combined are some of the largest and most persistent planters of longleaf pine in Alabama. Back when everyone else seemed to give up longleaf, they maintained an interest. Well, Tom Croker didn't give up. Ed Leigh said, "It just makes good sense". Longleaf is resistant to cronartium, southern pine beetle, tip moth and most other insects and diseases that infest, infect and kill other pine species. While it is susceptible to brown spot, this is mostly under an overstory in natural regeneration. We all know that fire will help control that. On site prepared lands, longleaf will emerge from the grass stage in 2 or 3 years - not 7 as some predict. With good seedlings, planted deep enough, you get good survival. On longleaf sites, after 30 years, longleaf volume will equal or surpass other species - and it is the quality species.

Before this conversation I hadn't really thought a lot about longleaf. We grow them in the nursery - where they are more trouble than other species - but that was about the extent of my thinking. Since then I was on one of our small state forests and paid close attention to longleaf - and was inspired by it. It is truly a quality species and we need to perpetuate it in Alabama. It provides a quality tree which will always have a place in the market place at premium prices.

From my conversation with Ed Leigh it seems as though we have no problems - only great opportunities with longleaf. I'm sure this may be a slight exaggeration but I hope this conference can solve all the remaining problems whether actual or imagined and we can perpetuate longleaf pine - the premier species - on longleaf sites in Alabama.

On behalf of all Alabamians present I welcome you to our great state. Our slogan says "We Have It All" ---and what can I add to that - we hope you have a pleasant stay in Alabama and encourage your full participation in this important conference.

---

[1] State Forester, Alabama Forestry Commission

HISTORY AND POTENTIAL OF LONGLEAF PINE

Thomas C. Croker, Jr.[1]

Centuries before the birth of the United States in 1776 the longleaf pine forests were important in the lives and fortunes of southern people. The forest that has meant so much to the southern economy has been reduced to less than a sixth of its original acreage. Recent events suggest that this trend can be reversed.

The longleaf pine story is a fascinating saga of southern history. It begins in the virgin forest.

THE VIRGIN FOREST

Open and parklike the virgin forest dominated some 60 million acres of the southern landscape. The forest provided an ideal habitat for deer and other wildlife. Its range extended from southeastern Virginia to east Texas. Ecologists classify longleaf as a fire climax type. Foresters estimated that the original stands contained over 400 billion board feet of the strongest building material in America.

THE REDMEN

These forests provided many of the necessities of life for the woodland Indians: fuel for warming and cooking fires; torches; and building material for lodges and other structures. Deer from these woods furnished food, clothing, shelter, and an important trade item. The Indians' clearings for gardens and field crops did not reduce the forest acreage much and their hunting fires tended to maintain its open character.

THE WHITE MAN COMES

The first white men to enter the longleaf forests were Spaniards in search of gold. Escapees from the herds of hogs they brought along are the ancestors of the razorbacks that have been such a scourge to longleaf pine seedlings.

English pioneers that came to the east coast were seeking home sites instead of gold. These forests furnished them material to build homes, other buildings, and fences as well as open range grazing for their livestock. Imitating the Indians they set fires to control movement of cattle and maintain the open character of the forests. The virgin forests and life style of these pioneers have been described by William Bartram and other writers.

---

[1] Longleaf Pine Specialist, Brewton, Alabama.

THE TURPENTINERS

The first commercial enterprise of the European settlers was the production of pitch and tar from longleaf pine heartwood. Later living trees were tapped for their gum which was distilled to produce rosin and turpentine. Until 1830 all gum was shipped to England for distillation.

To collect the gum a box was cut in the base of the tree. This was very wasteful and a new technique was needed. Toward the end of the nineteenth century W. W. Ashe and Dr. Charles Herty developed a more conservative cup and gutter system that is still used. After World War II researchers developed improved methods: bark chipping, acid stimulation, and improved tools.

Another form of naval stores is the extraction of turpentine and rosin from stumpwood. This is the final contribution of the virgin forest to the southern economy.

THE RIVER ERA

Pioneer timbermen depended on water to transport their logs and power their mills. William Bartram described a typical operation on the Savannah River in Georgia in the 1700's. Logs were dragged to the river bank with oxen hitched to "timber wheels." There slaves squared them and dumped them into the river to be floated down to Savannah for export to the West India market.

The first mills were powered with water. Besides sawing lumber they ground corn and cleaned rice. Later they were powered with steam but were located near water so logs could be rafted to them.

The river era came to an end near the end of the nineteenth century with the advent of the railroad logging.

THE RAILROAD LOGGERS

As the nineteenth century waned strange sounds were heard in the longleaf forest. The scream of locomotives, the din of power skidders dragging logs to the railroad siding, and the chant of track-laying crews signaled the start of a new era. The railroad loggers had come south to harvest a bonanza of yellow pine timber.

In the scurry and bustle of the times little thought was given to growing a second crop of timber. However a few, encouraged by pioneering foresters such as Austin Carey, did modify their cut and some provided for fire protection.

The railroad loggers swept across the longleaf belt from east to west leaving millions of acres of stump orchards. Most of the virgin stands were cut out by 1930.

THE GREAT DEPRESSION

The Great Depression plumbed unusual depths in the land of the longleaf pine. Banks and businesses dependent on the mills failed. Suffering was most acute among the forest workers left behind when the mills cut out. Many squatted on cutover company lands and scratched out a meagre existance with submarginal farming and scrawny livestock.

Into this dismal picture a wilderness army of young men came bringing renewed hope. The CCC established many 200-man camps in the longleaf belt. Large tracts were fenced against the destructive razorbacks, millions of seedlings were planted, roads and towers were built, and wildfire was surpressed.

The CCC was an important milestone in the longleaf pine story but there was another development of equal importance. In the thirties the battle between the prescribed burners and the fire exclusionists reached a showdown. After researchers of the Southern Forest Experiment Station confirmed the value of controlled burning the practice gradually spread throughout the longleaf belt and later to other forest types.

THE SECOND FOREST

Like the fabled phoenix bird a second forest arose from the ashes of the virgin forest. Much restricted in acreage and often poorly stocked nevertheless it began to contribute to the southern economy. To log this forest a new breed of timbermen employing automotive trucks replaced the railroad loggers.

A PLACE IN THE SUN

In the 1960's a modern day army of men and machines moved into the longleaf forest clearcutting and replanting with loblolly or slash pine. The second growth longleaf including some well-stocked stands are disappearing from the South at an alarming rate. Why is this being done? There are two main reasons. First is the difficulty of regenerating new stands; and secondly, the slow initial growth of longleaf seedlings. However recent developments suggest that this trend can be reversed. Researchers have perfected a reliable natural regeneration system and some success has been achieved where high quality stock is carefully planted on well prepared sites. Under some conditions direct seeding works reasonably well. Geneticists have discovered strains that are resistant to brown spot and capable of fast height growth. Encouraged by these developments some foresters and landowners realizing the inherent resistance of longleaf to the hazards of the southern environment and the many other desirable attributes of the species are beginning to favor longleaf in their management plans.

QUESTIONS AND ANSWERS

Q--Make comment on hardwood understory control in longleaf pine natural regeneration besides fire.

A--The best method depends on many site factors, cost restraints, and the like. A promising new method includes the use of Velpar pellets distributed at 6 foot intervals by hand or otherwise applied. Suitable treatment methods are being tested now. Information can be obtained from the Forest Service Lab at Auburn. Other suitable methods include stem injection with Tordon or a 2,4-D Amine, or other suitable chemical. Light 7-ton choppers have been used in some situations but there are two cautions. This must be delayed until after the seed cut in a shelterwood system and care must be taken to avoid damage to the seed trees.

Q--Is there a commercial row seeder available?

A--I believe Whitfield Machine Company at Mabelton, Georgia produces one.

Q--What factors would account for the loss of a naturally regenerated stocking (40,000 seedlings per acre) of longleaf pine in a typical Florida flatwoods area?

A--I cannot say for sure without more information and an on-the-ground check. There are many possibilities including drouth, rabbit or insect damage, competition, and numerous other factors.

Q--How long in millions of years has longleaf grown in the South?

A--In my research into the history of longleaf pine I have never found anyone who even tried to speculate on the answer to this. I can only say that ecological studies indicate that it is a pioneer species that is one of the earlier arrivals on alluvial sand deposits.

NATURAL REGENERATION OF LONGLEAF PINE

William D. Boyer[1]

Abstract.--Natural regeneration is now a reliable alternative for existing longleaf pine forests. The shelterwood system, or modifications of it, has been used experimentally to regenerate longleaf pine for over 20 years, and regional tests have confirmed its value for a wide range of site conditions. Natural regeneration, because of its low cost when compared to other alternatives, should be particularly suited to the needs of the small forest landowner.

Tough regeneration problems have given longleaf pine a bad reputation among foresters, and as a result longleaf is commonly replaced, upon harvest, by other species. Major problems associated with longleaf natural regeneration include:

(1) Poor seed production. Good seed crops are few and far between. With scattered seed trees, the land is out of production until a good seed crop comes along. By then, hardwood brush may have occupied the site.

(2) Uncertain establishment. Relatively few of the dispersed seeds become established seedlings. Several successive seed crops may be required for acceptable regeneration.

(3) Poor survival of established seedlings. This problem is particularly acute during seedlings' first year.

(4) Slow seedling growth. During the familiar grass-stage, which may last from 3 to more than 10 years, land is essentially out of production. Slow growth primarily results from competition and the brown-spot needle blight.

Yet despite all these obstacles, millions of acres of second-growth longleaf pine sprang up when old-growth timber was cut. Whatever nature can accomplish so well by chance, surely the forester can improve on by design. Observations of longleaf regeneration in nature led to the hypothesis that some form of the shelterwood system of natural regeneration might be most suited to the requirements of this species (Croker 1956). More than 20 years of the follow-up research on longleaf regeneration ecology has demonstrated that a shelterwood system can regenerate existing longleaf stands at low cost and with a high degree of reliability. With modification, it is applicable to a wide range of site conditions and management goals. Areas regenerated in this manner have ranged from large blocks to patches as small as ¼-acre. The research has led to published guidelines on the application of the shelterwood system (Croker and Boyer 1975).

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[1] Principal Silviculturist, George W. Andrews Forestry Sciences Laboratory, Auburn, Alabama, maintained by the Southern Forest Experiment Station, Forest Service, USDA, in cooperation in Auburn University.

Perhaps the most important consideration for successful natural regeneration is the proper prescription and careful timing of the necessary operations and cultural treatments. Given a longleaf pine stand approaching harvest age, regeneration by the shelterwood system would typically be applied as follows.

(1) Preparatory cut.--This cut, the first in a three-cut shelterwood regeneration system, is primarily an improvement cut leaving 60-70 sq. ft. of basal area per acre of the best dominant-codominant trees. It will promote development of larger crowns on residuals. A hardwood understory, if present, is removed or deadened, and periodic prescribed fires keep sprouts and shrubs under control. A well-managed pine stand, however, should not need a preparatory cut.

(2) Seed cut.--This cut, made about 5 years ahead of the planned harvest date, further reduces stand density to about 30 sq. ft. of the highest quality trees and creates the shelterwood stand, which will provide the seeds for the next generation. Maximum per acre seed production is reached under this density, and in good seed years will produce almost 3 times as many seed as a stand with 10 seed trees per acre. The regeneration area is not out of production during the wait for a seed crop. Although the seed cut may halve stand density, per acre volume growth is reduced by only about one-third, and all this growth is on premium trees. Increased seed production stimulated by release will show up 3 years after the cut. Another advantage of the shelterwood stand is that it produces enough needle litter to support hot prescribed fires for brush control and seedbed preparation.

(3) Monitor seed crops.--Within each area, mark 40 to 50 representative sample trees for annual springtime binocular counts of both flowers (which predict next year's crop) and conelets (which predict this year's crop). Make the counts just before female flowers are obscured by new foliage. Conelet counts can reliably predict not only seed production, but also number of established seedlings, provided the area has had a seedbed burn. Flower counts are of marginal value in predicting the size of fair to good seed crops, but they invariably reveal seed crop failures.

(4) Seedbed burn.--Apply this burn within a year of a good seed crop. The burn removes surface litter and exposes mineral soil.

(5) Regeneration surveys.--Schedule annual winter seedling stocking surveys. The usual criterion for regeneration success is 6,000 or more seedlings at least 1 year old. This number will absorb logging mortality of up to half the stand and still provide enough survivors so that the superior 10 to 20 percent of the seedling stand will provide at least 500 crop trees per acre. First-year seedling survival is too uncertain to base success on newly established seedlings. The proportion of ¼-milacre sample plots stocked with one or more seedlings will indicate the number of seedlings per acre (Boyer 1977). A ¼-milacre stocking percent of 63 is equivalent to 6,000 seedlings per acre.

(6) Overstory removal.--When an adequate seedling stand is established, the overstory can be harvested. Timing of the cut usually is not critical, as long as it is done before crop seedlings begin height growth. Seedlings can tolerate

overstory competition for a long time if they are protected from fire while small (0.3-inch or less in root-collar diameter). If you have a choice, however, removing the overstory at seedling age 1 or 2 should have the least impact on the new stand (Maple 1977).

(7) Post-harvest treatments.--Two or more years after overstory removal, the seedling stand may need to be burned for control of hardwood brush or the brown-spot needle blight. The need for brown-spot burns should be based on infection surveys of crop seedlings (Croker 1967). The disease condition of the extra seedlings has no importance to management. Normally, about 10 to 20 percent of a seedling stand will be resistant to brown-spot.

Natural regeneration should be considered a viable alternative when planning the harvest and regeneration of an existing longleaf pine stand. This approach should be particularly attractive to landowners who, because of financial considerations or management goals, do not want to make the heavy capital investment now required by site preparation and planting.

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DIRECT SEEDING LONGLEAF PINE

H. E. Baxendale [1]

Abstract.--Longleaf pine has been a much neglected species in reforestation in the South mainly because of the problems associated with planting. Our experience has shown that by the use of direct seeding it is possible to successfully reproduce this species and it might well be considered when the forest manager is choosing his species for regeneration.

We first started direct seeding longleaf on an experimental basis in 1959 when we seeded a 17-acre tract by hand with a cyclone seeder on spoils banks in Walker County. It was not until 1968, however, that we started aerial seeding on an operational basis.

Most of the direct seeding of longleaf we have done has been on spoils banks although we have used it to some extent to regenerate clearcut areas that were originally in longleaf.

We found that its use on spoils banks has certain advantages over loblolly, the species that is usually used for reclamation. Loblolly often has a chlorotic condition in spots during the first four or five years of growth which may be caused by a low pH. Longleaf is not so affected, apparently making vigorous growth from the start.

Due to the absence of competition and because brown spot needle rust is not a problem, longleaf will usually start making height growth the second or third year after germination on spoils banks compared with one to three years longer when seeded on undisturbed sites and then only after a prescribed burn.

We have had greater success seeding in December rather than the early spring for reclamation although the last two severe winters frost heaving has been a problem.

The provisions of the new Federal Strip Mine Reclamation Act which went into effect in May of this year call for the immediate establishment after grading of a ground cover to prevent erosion. This would be some type of grass. The enforcement of this part of the act in my opinion would make the direct seeding of pine all but impossible due to the competition created by the ground cover. This will almost preclude the future use of longleaf for reclamation of spoils banks because of the difficulty of planting.

A portion of the seed we have been using we have collected ourselves from a longleaf stand in Bibb County. We used a pecan tree shaker to shake the cones out of the trees. After collecting, we contract with one of the two local tree seed companies to process the cones and treat the seed. Treatment is with Bill Mann's standard formula (1) using Arasan 42-S, Endrin 50W, aluminum powder and a latex sticker according to the directions he gives in his publication, "Direct Seeding Longleaf Pine." The seed is kept in cold storage until used.

---

[1] Chief Forester, Southern Raw Materials Property, United States Steel Corporation, Birmingham, Alabama.

We have always used a helicopter for aerial application and we now specify a Simplex seed dispersal apparatus, as we have had problems with a type that employs an auger beneath the seed hopper. The auger would become clogged up and also would tend to injure the seedcoat thus affecting viability of the seed.

We prelocate the flagging stations and flag all except small areas which are free flown.

Seeding on undisturbed land is done after the site has been prepared by shearing and burning. The area is again burned the second or third year after seeding to control brown spot and reduce competition and again the fourth or fifth year if needed.

To date we have seeded about 3,000 acres for reclamation and 1,000 acres reforestation.

The superior qualities of longleaf make it an important tree that should not be overlooked when the land manager is choosing the species to use for reforestation. Our experience has shown that it can be successfully established by direct seeding so it could make a valuable contribution to our growing of the third forest.

LITERATURE CITED

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QUESTIONS AND ANSWERS

Q--From an economic standpoint what acreage size is the breaking point between hand seedling and helicopter seeding? Use the $3/hr. minimum wage rate in hand seeding.

A--I believe from 300 to 500 acres would be the breaking point between hand seeding and aerial seeding. For any acreage agove this size it would be more economical to aerial seed.

Q--Did you know that DuPont no longer produces Arasan 42-S? The Southern Station of the US Forest Service is attempting to register another formulation of Arasan.

A--I did not. I certainly hope it will be possible to come up with a suitable substitute.

Q--With 2.6 lbs. per acre of longleaf seed, what number of seedlings per acre was noted in average survival?

A--Survival has been running from 1,500 to 2,500 seedlings per acre.

Q--Is there any plan by your company to change or circumvent the law on planting grasses so that direct seeding can continue with longleaf?

A--Unfortunately, we know of no easy way to change the law and we certainly do not plan to circumvent it.

Q--Will fresh site preparation by double chopping be adequate without burning for aerial seeding success?

A--Only if mineral soil is exposed sufficiently. It is necessary for the seed to get to mineral soil.

Q--Can you aerial seed a one or two year rough?

A--Possibly, but the chance of success decreases with each additional year of rough.

Q--What site preparation is necessary to insure seedling establishment?

A--Any treatment which will expose the mineral soil, and control competing vegetation. Among the methods used are burning, shearing, disking, or chopping.

Q--What type of soils are in the Alabama mining spoils? Are they all suitable for longleaf?

A--The soil which is left on the surface of the spoil has been a mixture of shale and clay. Longleaf has grown vigorously on all the areas on which it has been tried.

PROGRESS MADE IN NORTH CAROLINA IN PLANTING LONGLEAF PINE

O. C. Goodwin[1]

Abstract.--Longleaf pine plantations are being successfully established by the North Carolina Division of Forest Resources and two private subcontractors on cutover Sandhill and Coastal Plain sites by winter plantings of bare root and summer plantings of containerized seedlings. Survival is improved when seedlings are hand planted in shallow fire-line furrows, or machine planted in strips scalped by front tractor mounted V-blade. Reinforcement planting is required on some sites to bring the stocking up to 400 to 450 uniformly spaced seedlings.

Additional keywords: Containerized seedlings, tree planting, site preparation, *Pinus palustris*.

In recent years we have made some progress in successfully planting longleaf pine (*Pinus palustris* Mill.) in North Carolina. Poor and erratic survival has long been a problem in planting this species on cutover, scrub oak and other adverse Sandhill sites, not only in our state but throughout the South. Although in 1969 we were successfully hand planting longleaf pine in disked, undisturbed furrow centers at our Bladen Lakes State Forest, failure was often the case in planting this species on privately-owned lands. Our Forestation Unit was funded and organized in this same year by our state legislature to provide complete custom site preparation and tree planting services at cost for private landowners. Consequently, at that time we seriously began to take a closer look at various planting practices to determine how we could improve upon the contractual longleaf pine planting survival rates.

Among those practices observed were the extensive longleaf plantings by the U. S. Forest Service on the Savannah River Atomic Energy Commission Project in South Carolina, those by the Fort Bragg Military Reservation, and those by our Bladen Lakes State Forest in North Carolina. Robbins (1969) concluded from these observations that if certain practices were adopted by private contractors, including our Forestation Unit contractual services, adequate survival and satisfactorily stocked stands of longleaf pine could generally be obtained on our adverse Sandhill sites. These practices were gradually put into use, and they have contributed to better longleaf planting jobs being done, thereby resulting in more successful longleaf plantations.

About this same time we began to investigate the use of containerized seedlings to overcome survival and growth problems of hard-to-plant species and to extend the regular planting season of pines. We began installing containerized seedlings plantings tests in July 1972, and longleaf pine tubelings were included in these tests. (Goodwin 1974).

---

[1] Senior Project Forester (Pine Silviculture), Forest Resources Division, N. C. Department of Natural Resources and Community Development, Raleigh, NC

Recent experiences of the North Carolina Forest Service in planting both bare root and containerized longleaf pine seedlings as well as our future plans are described in this paper.

PLANTING METHODS

Experience with various methods of planting longleaf pine has been gained at our Bladen Lakes State Forest located in the upper coastal plain and by our Forestation Unit on private landownerships located in the Sandhills region. They are described separately because they differ in many respects:

Bladen Lakes State Forest

Throughout the state, most of our contractual planting failures have been a result of poor planting labor or adverse weather conditions. At Bladen Lakes State Forest, there is good control over planting labor and planting scheduling, resulting in our most successful longleaf planting.

Basically, only their site preparation method has changed in the last six years. They have discontinued using a bush and bog throw-out disk, which leaves an undisturbed planting center 6 to 12 inches lower than the surrounding soil, and are now chopping, burning, (where site warrants such) and bedding all clearcut areas. They have gone to bedding primarily to reduce wiregrass competition and hopefully to reposition the A-1 soil layer by pushing it from between rows into the bed. Site preparation is still done preferably in the summer and fall.

Seedlings are still graded by culling out all seedlings having root collar diameters smaller than 1/4 inches. Therefore, only good quality seedlings are planted. Excessively long lateral roots are still root-pruned, and the tops of seedlings are clipped to approximately 3 inches length. Only bare-rooted seedlings are used, and they are mud-dipped and planted at 7x7 foot spacing on the apex of the bed. Containerized longleaf seedlings have been successfully test planted there, but they have not been planted operationally because of their good results with bare-root plantings. Practically all longleaf seedlings are hand planted, because exceptionally good sites are required for machine planting. Longleaf is planted at close spacing of 7x7 feet, not to increase survival, but to make possible early thinnings for the treated fence post market.

Forestation Unit and Private Contractual Services

Both 1-0 bare root and containerized longleaf seedlings are used by the Division of Forest Resources in providing planting contractual services to private landowners. Only our Forestation Unit is planting containerized seedlings on a limited basis. Private contractors do most of the hand planting and we do all of the machine planting. Each type of seedling will be discussed separately:

1-0 Bare Root Seedlings.--Most private contractors have discontinued planting longleaf pine, because they are unable to afford the high cost of machine planting equipment. Also they do not want to assume the risk of poor survival for the low margin of profit involved. In fact, only two private contractors still plant longleaf. This has resulted in our Division of Forest Resources crews becoming totally responsible for all the machine planting in our Sandhills region. However, for planting other pine species we relegate our crews to providing contractual services for those areas where no contractor exists or to planting acreages that are too distant or too small to be economically feasible for a private contractor. Moreover, we assume the risk if longleaf survival falls below 70 percent, and must reinforce plant where necessary to provide a minimum acceptable stocking of 400 to 450 uniformly spaced seedlings per acre at no extra charge. This guarantee only applies for longleaf seedlings planted in a fire plow furrow or where the soil is scalped with a front tractor-mounted V-blade. Better survival definitely results where competition from grass, weeds and brush has been removed. Contractual bedding is not done as it is not necessary for machine planting of longleaf on Sandhill soils.

We have found that the Case 1150, HD-11 and HD-15 crawler type tractors, equipped with a front mounted V-blade and pulling a Forestland tree planter will scalp a 4 to 8 foot wide strip and plant the bare rooted and containerized seedlings at the same time. The HD-15 works better on the rougher areas. Machine planting appears to be the most successful and economical method. The practice of preparing furrows not deeper than four inches, with a fire plow on the contour in late Spring or summer, and planting at 700 to 800 seedlings per acre the following January is generally successful.

Seventy percent is considered good survival even in the best years; normally it ranges between 50 and 60 percent. Seedlings are planted at 5x10 foot to 6x10 foot spacing in order to obtain the required 400 to 450 living seedlings after the first growing season. The seedling is planted either with the root collar at the ground level or with the bud covered 1/4 inch but no more than one inch to allow for soil washing. If the root collar is exposed, mortality will occur within a few weeks of planting. Planting is generally done from December to April unless the ground is frozen or the soils are very dry. We have found that we can extend the normal season through May by storing lifted seedlings up to 1 1/3 months in refrigerated trucks. This year we planted through June in order to get the planting job done.

Planting failures have been primarily caused by extremely dry soil conditions during or after planting, by frozen ground for several days or weeks after planting and by poor planting and handling of seedlings. On areas that require burning, there should be at least a 3 months interval before planting 1-0 seedlings. Summer burning has resulted in high mortality of summer planted containerized seedlings by creating very high soil temperatures at the root collar. We have stopped burning on those areas where containerized seedlings are to be planted during the summer unless it is absolutely necessary to prepare the site.

Seedlings of poor quality, and having less than 3/8 inch root collar, are culled-out before being planted by our Forestation Unit. Also the needles are clipped back to approximately one-half their length and the roots pruned with a sharp knife or hatchet. Previously when seedlings were clipped in the beds, it was difficult to get a hold of the seedlings to lift them and this practice was discontinued.

Quality control is carried out by supervised Forestation crews, who plant only good quality seedlings at the proper depth on moist mineral soil when feasible. An innovation used by our Forestation Unit is the "Zip Stick." This tool or stick is named after Forestation Forester Don "Zippo" Robbins, who insists that it be used on every machine planting planting job to insure that every seedling is properly planted when and where practical. Walking and checking the rows behind the planting machine or crews, one can replant improperly planted seedlings by using the pointed "Zip" stick as a hand planting tool. It can also be used to check spacing and the number of trees per acre on 1/300th acre plots.

Other quality control measures used are packing the seedlings in Kraft bags containing three or four handfuls of wet hydromulch and shipping them in refrigerated trailers to prevent drying, freezing, and overheating. Cooling is required only on hot spring days. The seedlings are unpacked at the planting site, graded, needle pruned, root pruned, dipped in water and then repacked so that the roots do not become dry. Bundles are always laid flat with ventilation sticks placed between the bundles and kept out of the sun. Only a few seedlings are carried at a time in the canvas bags in which water or a mud-slurry is carried. Wet burlap bags are placed over the seedlings in the planting machine to prevent drying of roots. Our Forestation foresters believe that extra care taken in protecting seedlings from heating, freezing and drying is one of the most important things to be done to improve survival.

Improved seedling quality from our Goldsboro nursery has helped improve survival of longleaf plantings. We try to seed at 15 per square foot using the So-Rite EZ-Flo fertilizer distributor, and to thin spots in beds where this number is exceeded. Our major seeding problem is that there is not an accurate seeder available for use with longleaf pine seed. Half of our 3.4 million crop is seeded in the spring and grown for 9 months and the other half is fall seeded and grown for 12 months.

The fall-seeded crop has fewer culls, as many of the seedlings are up to 1/2 inch in root collar compared to 1/8 to 1/4 inch for the spring seeded crop. The only difference is in size. Root pruning to 5 to 6 inches is done the last week of August or first week of September. The fall crop needles are barely clipped with a bush hog prior to lifting to reduce weights. Our only problem is with chlorosis from heat during the hot months of July and August, but the seedlings green up when the weather turns cool.

Containerized Rootrainer Seedlings.--A spring and summer crop of containerized longleaf seedlings are grown in the greenhouse for 10 to 12 weeks in the Spencer-Lemaire Rootrainers (formerly called book planters) and are hand and machine planted following the same general practices as for bare root seedlings. The main exception is that they are planted at age 10 to 16 weeks during the growing season to extend the regular bare root planting season.

The first two crops were planted in August and October 1977. This year another crop was planted in late August and early September and another crop is scheduled to be planted in October. They are still being considered on a trial or experimental basis by our Forestation Unit primarily because of logistic problems. A total of 91,000 Rootrainers will be planted this year.

The Spencer-Lemaire plastic Rootrainers that we use are of the Ferdinand book style. There are 6 cavities per book of 3/4" x 3/4" x 4" size (2 cm x 2 cm x 10 cm) and containing 2.5 cu.in. (40 ml) volume. Seventeen trays or 102 cavities are held by each 8 1/2" x 14 1/2" x 4" high (22 cm x 37 cm x 10 cm high) polypropylene trays. A 3 to 1 mix of sphagnum peat and horticultural grade vermiculite growing media is used (Goodwin Sept. 1975).

Rootrainers are usually grown in the greenhouse for 5 to 6 weeks and then moved to outdoor benches where they are hardened or conditioned for another 5 to 6 weeks by applying smaller amounts of water and nutrients. They are usually shipped by pickup or stake body trucks to our County Ranger headquarter sites and stored in shade under trees on the ground. They are thoroughly watered daily and transported daily in loads of 6,000 to 7,000 seedlings by covered pickup trucks to the planting sites. A pointed dibble, shaped the same size as the container, is used to hand plant Rootrainers in moist soil. A standard tree planting bar or the Finnish Pottiputki planting tool must be used when soils are dry to keep the hole open long enough to plant the seedling.

Generally, one man punches the hole with the dibble or bar and another worker places the root plug in the hole. A tray of Rootrainer seedlings is carried in one hand, and they are easily pulled with the other hand from the container cavities. The soil media in the root plugs generally adheres well together while being planted if the media is moist. Hand planting the small root plugs is much easier than planting the larger rooted 1-0 seedlings, except for their bulkiness and the discomfort of the hot summer weather. When they reach 13 to 15 weeks age, crossover of lateral roots between containers causes a root entanglement problem.

When Rootrainers are machine planted, the books of seedlings are removed from eight trays and carried in two metal boxes facing outward on the planter. Then the two droppers can grab a book quickly, jerk the seedling out of the book, and place it in the planting slit. An International 674 rubber tired farm tractor pulling a two-man Whitfield tree planter has been found to work very well in planting Rootrainers. A 5-man crew can plant as fast as two men can drop the seedlings at a five-foot spacing. They can plant 7,500 per day. However, the area must be lightly scalped with a fire plow prior to planting as this tractor cannot handle a V-blade.

PLANTING RESULTS

Except for 19 percent survival occuring in the 1976-77 planting season and caused by a drought period in April, survival rates up to 80 percent have been consistently obtained at the Bladen Lakes State Forest. Survival averaged 72 percent on the 121 acres planted on beds and on the 10 acres of burned area planted in the 1977-78 season. Although bedding has apparently not improved survival rates, early growth is better on beds than in furrows on coastal plain sites. The state forest having the ability to exercise tight control over the quality of their planting jobs and to schedule their operations during favorable conditions are factors in their success with longleaf plantings.

Although they plant about the same number of seedlings per acre (889) as our Forestation Unit (600 to 800), they use a spacing of seven feet between rows compared to the 10 foot spacing used by our Forestation Unit. Wider spacing between rows is used on private ownerships primarily to provide access for our fire plow units when protecting plantations from fire.

In 1977, our first year of planting containerized longleaf seedlings on private landownerships, eighteen percent or 141 of 785 acres of the total new areas planted in the Sandhills region were planted with Rootrainers (Table 1).

First year survival counts have not yet been made but spot checks indicate good survival. Because of heavy mortality (0-30% survival) caused by frozen ground for three weeks and by spring drought, two-thirds of the acres planted with longleaf 1-0 seedlings in the 1976-77 planting season required either replanting or reinforcement planting in the 1977-78 season. Of the 1,313 total acres planted last year by our private contractors and our Forestation Unit, 455 acres had to be replanted and another 213 acres reinforced planted to meet our guarantee of 400 to 450 uniformly stocked trees per acre (Table 2). This was the worst year that our people can remember. Heavy mortality was caused by the sand freezing to a depth of two feet in February followed by a hot, dry spring. In the 1975-76 season when normal weather conditions prevailed, excellent survival was obtained and not any replanting or reinforcement planting was necessary. Indications are that good results will be obtained for the 1977-78 planting season. Therefore, we have experienced one disastrous season out of the last three seasons.

Table 1.--Longleaf pine seedlings planted in 1977-78 season by type of seedlings and method planted on new privately-owned areas in Sandhills region

Type of Seedling	Areas	Acres	Seedlings	Hand Planted	Machine Planted
	- - - - - - No.	- - - - - - -		- - - - - - - Acres	- - - - - - -
1-0 seedlings	26	644[a]	451,000	283[b]	361[c]
Percent	75	82	86	36	46
10-20 week old Rootrainer Seedlings	5	141	74,000	0	141[d]
Percent	25	18	14	0	18
Total	31	785	525,000	283	502

a/ Only 81 acres on non-site prepared areas or of open field planting was done.

b/ All hand planting was done by private contractors.

c/ Only 21 acres done by private contractors.

d/ All machine planted on V-blade scalped area at 7x10 foot spacing.

Table 2.--Longleaf pine 1-0 seedlings planted in 1977-78 season in Sandhills region and 1976-77 acres replanted and reinforced planted by site preparation and planting method used a/

Site Preparation Method	New acres planted Hand	New acres planted Machine	Replanted Hand	Replanted Machine	Reinforce planting Hand	Reinforce planting Machine	Total planted Hand	Total planted Machine
	- - - - - - - -	- - - - - - - -	- - - - - -	-Acres planted	- - - - - -	- - - - - -	- - - - - -	- - - - - -
No site preparation	26	0	32	0	23	0	81	0
V-blade scalping	43	361	203	40	136	0	382	401
Fire line furrowing	83	0	82	0	54	0	219	0
Bladed and piled	85	0	0	0	0	0	85	0
KG and burning	0	0	23	0	0	0	23	0
Burning only	46	0	0	0	0	0	46	0
Disking	0	0	54	21	0	0	54	21
Total acres	283	361	394	61	213	0	891	422
Percent of total	21	27	30	5	16	0	68	32

a/ Data herein illustrates situation resulting from three weeks of frozen ground and very dry conditions in 1976-78 planting season. In the previous year, when favorable weather conditions occurred, there was no need for any replanting or reinforcement planting.

Because practically all of the reinforcement planting and replanting is done by hand crews, 68 percent of the total longleaf 1-0 seedlings were hand-planted last year. On the otherhand, 62 percent of our new plantings last year was done by the combined V-blade machine planting method. Hand planting in fire line furrows was used on only 13 percent of the new acres planted (Table 2). It is used only when the areas are too rough for V-blading and machine planting.

Where we are successful in planting longleaf 1-0 and Rootrainer seedlings, 50 to 80 percent survival for both hand and machine planting is common and can be expected under normal rainfall and temperature conditions and when a good planting job is done. Unfortunately, it is logistically very difficult to stop or delay our contractual crews from planting during dry periods and soil conditions. To keep them working, sometimes we must plant during unfavorable conditions and take a chance of getting favorable weather conditions very soon after planting.

The total cost of machine planting containerized seedlings averages approximately \$55 per acre. The cost of machine planting for 1-0 seedlings runs between \$45 to \$65 per acre. Costs of hand planting containerized seedlings (\$50-\$60 per acre) are slightly more than those for 1-0 seedlings (\$39-\$45 per acre). Although they are easier to plant and consequently can be planted quicker, their extra cost of \$8.00 more per thousand and the extra time required to supply the planting crew with Rootrainers and collect empty trays offsets this advantage. Our nursery sells 1-0 seedlings for \$14 per thousand, and our greenhouse facility sells longleaf Rootrainer seedlings for \$22 per thousand. All seedlings are sold at actual production cost.

DISCUSSION

It appears that better quality nursery seedlings combined with bedding and furrowing or scalping practices have levelled-off the site differences and improved overall survival of bare root planted longleaf pine. Better care and handling of seedlings and other quality control practices have also been reflected in better survival and growth. Planting at close spacings of 5x10 to 6x10 feet has helped overcome low survival rates, and also to obtain adequate stocking when survival falls from 70 percent to 50 or 60 percent. At every step, a better planting job must be done more so for longleaf than for the other Southern pine species. Fortunately, we are allowed to use CETA workers employed by the counties with federal funds to do reinforcement planting at no cost to us except for their expenses. This amounts to a savings of \$3.00 per hour for planting labor.

As for planting containerized longleaf pine seedlings, based on my experimental plantings, I believe they are superior to bare root seedlings if used properly (Goodwin 1974). After three growing seasons, nine-weeks old summer-planted longleaf pine tubelings equalled winter-planted 1-0 seedlings in survival and were significantly taller. Their third season survival was 80 percent and their height averaged 1.2 feet. This is compared to 58 percent survival and .4 feet height for the bare root seedlings (Goodwin 1976). After five growing seasons, their survival continued to average over 80% for all 8 tests. July planted tubelings on beds averaged 5.2 feet compared to 3.7 feet in height for 1-0 seedlings.

While tubeling performance was entirely satisfactory, tubes restrict the growth of lateral roots to some extent, and the tubes can be used once. Tests installed using the Spencer Lemaire Rootrainers (book planters) in 1973 indicate after two growing seasons that longleaf pine root plugs have equalled or surpassed the growth of 1-0 longleaf bare root and tubeling stock. Seedlings grown and planted in the summer months have continued to give the best results (Goodwin 1975).

After three growing seasons, this same test of longleaf Rootrainers has continued to equal survival and growth of tubelings and to outgrow bare root seedlings and one year old Japanese paper pot seedlings (Table 3).

Table 3.--Survival and average height of August-planted longleaf pine Rootrainer and tubeling seedlings and winter-planted longleaf 1-0 seedling in North Carolina Coastal Plain

Type of Seedling	First Season[a]		Second Season[a]		Third Season[a]	
	Survival	Terminal Buds	Survival	Height	Survival	Height
	Percent	Percent	Percent	Feet	Percent	Feet
Ferdinand Rootrainers (book planters)	95	57	94	.56	92	2.3
Ontario Styrene, split tubes	97	61	95	.50	93	2.3
1-0 seedlings	89	10	88	.18	87	.6
1 yr. old Japanese paper pot #408 seedlings	-	-	-	-	93	1.4

[a] Values are for the end of the growing season. Container seedlings had about two extra months of growing in the first year over 1-0 seedlings.

Although first year survival rates for the 1977 contractual jobs have not yet been determined, spot checks indicate survival should be about the same as for bare rooted seedlings planted this season. I expect these summer and fall planted Rootrainer plantations to follow the trend of my test plantings by equalling or even surpassing the height growth and resulting in more uniformity in height than for the bare root longleaf plantations.

A word of caution, Rootrainers should be held in the shade on screened-bottomed racks or benches and watered 30 to 45 minutes daily at or near the planting site and held until soil conditions are moist unless heavy showers or a good rainfall is forecast very soon after they are outplanted. Once the peat-vermiculite media becomes dry, it is very difficult to wet throughout again unless soaked in water.

Furthermore, the root plug should be planted just deep enough to cover the top of the plug with a thin layer of soil to prevent drying of the plug by the wicking-effect. Because they have no buds, care should be taken to not plant the seedlings too deep. Allowance should be made for having the soil ridge of machine planted seedling wash away from the seedling roots by planting them slightly deeper than hand planted seedlings.

The main disadvantage of hand planting containerized seedlings is their bulkiness. Generally since only one tray is carried at a time; only 75 to 85 seedlings are carried by the planter. Consequently, one man is kept busy needle pruning and supplying the planting crews with seedlings and in collecting the empty trays and containers. Machine planting is not faced with this problem as approximately 600 Rootrainers can be carried on the tree planter after the books have been removed from the trays.

Because Rootrainer roots are encased in moist peat-vermiculite soil media, their roots are not as subject to drying when outplanted as bare root seedlings.

An advantage of using containerized seedlings for reinforcement planting is that they have been found to "catch up" with the bare root seedlings, if planted the summer of the same season that the area was planted. Bare root seedlings used for reinforcement planting the year following the original planting will always lag behind the stand. Therefore, I recommend containerized seedlings be used for all reinforcement planting of both bare root and containerized seedling plantations. Furthermore, the beneficial effect of the site preparation is taken advantage of by avoiding having to wait until the winter planting season to do the reinforcement planting. Also by doing the reinforcement planting during the summer, the planting work load during the regular planting season is reduced.

Sample plots are taken by our District or County Rangers in bare root plantations in the fall to determine survival rates and the size of the spots or areas which might require replanting or reinforcement planting. However, at this time it is too early to sample the Rootrainer plantations, for they should be exposed to winter conditions and sampled early in the spring to determine if reinforcement planting is needed that summer.

CONCLUSIONS

I believe progress has been made in North Carolina in the art of planting longleaf pine. During normal weather conditions, we can successfully plant longleaf pine on adverse Sandhill and Coastal Plain cutover areas in North Carolina. We have learned that good quality seedlings must be properly planted on well prepared sites, and reinforcement planting may be required to obtain a minimum of 400 to 450 trees per acre. Either 1-0 bare root seedlings or 10 to 16 weeks-old Rootrainer containerized seedlings may be used, but the latter should be planted during wet periods in early summer and early fall. Best results of 80 percent survival for bare root seedlings are obtained on Coastal Plain sandy soils where quality control is strictly enforced. Survival up to 70 percent can be expected for bare root seedlings on the more adverse Sandhill sites. Frozen ground and droughty soils are still our worse problems. Based on three years of experimental tests, containerized longleaf seedlings can be expected to give over 90 percent survival under normal weather conditions. Hand planting in shallow fire-line furrows or machine planting in tractor-mounted V-blade scalped strips increases survival rates of both bare root and containerized seedlings although washing of loose sand is still a problem on some areas. Planting on beds gives similar survival rates to furrowing and scalping.

Both spring and fall seeding at 15 seedlings per square foot and root pruning to 5 to 6 inches in the beds produces good quality longleaf seedlings. It is of utmost importance that seedlings be handled with care from the time they are lifted, packed and shipped to the time they are planted. Total supervision of trained personnel is a must at all times and knowledgeable persons must make checks. Special care must be taken at all times to prevent freezing, overheating and drying of seedlings. After seedlings less than 1/4 inch at root collar are culled, the ones to be planted are needle-pruned by cutting off about one half their length. The buds should be planted at ground level and care taken to not cover them completely with soil. However, seedlings planted on very fluffy and loose soils should be planted slightly deeper to allow for soil washing away from seedlings and to prevent leaving the bud exposed to freezing weather.

During the next several years, we expect to continue planting 1-0 longleaf seedlings at about the same level and using the same methods we have found to work best. Presently, we are limited by the amount and condition of our Forestation equipment, and cannot plant much more. Funds in the amount of $100,000 received from the newly enacted state Forest Development Act, which assesses primary wood users on all timber annually cut, is being used to replace some of our old, worn Forestation equipment, and to acquire some new and better equipment.

Better Rootrainer planting conditions prevail in late spring and early summer; therefore, we plan to go to a late winter-early spring crop and a late spring-early summer crop of Rootrainers in 1979 for May and July plantings. We will try to avoid the very dry August conditions we have experienced.

We do not see the need now to expand our Rootrainer greenhouse production and planting of containerized longleaf seedlings. We plan to continue on about the same level until the problems with logistics can be worked out and more experience can be gained in handling and planting containerized seedlings. We do feel, however, that there is definitely a place for the use of containerized seedlings to supplement and complement our bare-root longleaf planting program. At the moment, we have been unable to locate a seed source for our 1980 crops, and this will curtail both our nursery and containerized seedling crops. We will grow only one million fall-seeded and one million spring-seeded crops that year because of seed supply and decreasing demand for longleaf seedlings.

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PLANTING QUESTIONS & ANSWERS

Q. Over the last 5 years, what is the annual acreage planted to longleaf in North Carolina?

A. We have grown an average of 3½ million seedlings each year and this would plant about 4,000 acres annually. Our Forestation Unit contractually plants 1,500 to 2,000 acres annually.

Q. What percent of your planting is with bare root stock?

A. Until the 1977-78 planting season, only 1-0 longleaf seedlings have been contractually planted by our Forestation Unit. Last season 82% were bare root seedlings and 18% Rootrainer containerized seedlings.

Q. What was the average monthly rainfall just before and after your 80 to 98 percent survival of containerized seedling tests?

A. I don't have such records but can say that I did not plant unless the soil had some moisture and that a good rainfall occurred within two or three weeks after the seedlings were planted. One test of tubelings and Rootrainers planted in October on fairly dry soil did not receive a good rainfall until four weeks later and resulted in only 55% survival.

Q. Have you established minimum soil content for minimum acceptable stocking success?

A. Yes, soil conditions should be moist unless heavy showers or a general rainfall is forecast within a few days after being planted. Unfortunately, our Forestation Unit has not always been able to schedule their planting accordingly.

Q. Have you considered not planting until you have adequate soil moisture and not gamble on anticipation of favorable moisture conditions?

A. Yes, but what do you do when you have the planting crews and equipment geared-up for planting?

Q. Do you produce containerized seedlings year-round?

A. Until this year, we have grown only a spring and a summer crop of longleaf seedlings, because during the winter we have been growing a full greenhouse of Fraser fir Christmas tree transplants. We do have the capability of producing containerized longleaf the year around.

Q. What is the oldest containerized seedlings that can be planted?

A. The oldest longleaf Rootrainers we have planted have been 18 weeks from germination. Root entanglement caused by cross over of roots between connecting cavities occurs at this age. I have planted one year old longleaf grown in Japanese paper pots and obtained the same survival and growth as with 12 week old Rootrainers. An advantage of containerized seedlings is that they can be held for long periods if necessary before outplanting.

Q. Do containerized seedlings need to be totally in the ground?

A. Yes, the root plug is planted so that it is slightly covered with sand to prevent loss of moisture by wick-effect of the root plug.

Q. Should 1-0 seedlings be planted so that after the soil washes away from the seedling the root collar will be at ground level or below ground level?

A. Yes, the important thing is that the root collar not be exposed.

Q. Can you completely cover the stem of longleaf containerized seedlings, including the bud, and still expect good survival?

A. Because they do not have buds and the stems are so short, they are usually covered when hand planted when heeling-in the seedling. When machine planted, covering of the bud is not a problem if the depth of the planting slit is properly regulated. Such a problem, however, may be caused by washed sand covering the small seedling and causing it to become smothered.

Q. Is your survival success with 1-0 seedlings improved by minimizing the time from lifting the seedlings at the nursery to planting them in the field?

A. I am not sure I can answer this question. Our Forestation Unit stresses the proper care and handling of seedlings to protect them from drying, heating and freezing from the time they are lifted until they are planted. However, I suspect that this is a factor causing some failures of seedlings planted by landowners and private contractors who delay planting and do not take proper protective storage measures.

LONGLEAF PINE SURVIVAL INFLUENCED BY SEEDLING SIZE AND LENGTH OF STORAGE

John B. White[1]

Abstract.--In a study with longleaf pine (*Pinus palustris* Mill.) in southern Mississippi, only seedlings with a root collar diameter (RCD) of 0.5 inch or greater gave satisfactory survival. Seedlings of 0.5 inch RCD can be stored for 3 weeks without loss in survival, and with storage of longer than 3 weeks survival drops off. Seedlings of 0.4 inch RCD are marginal for planting and those 0.3 inch RCD or smaller should definitely be discarded.

Additional keywords: Cold storage, Kraft polyethelyne bags, root collar diameter, machine planted, Kaolin slurry

Longleaf is considered one of the finest pines of the south, yet it has decreased from 60 million acres in colonial times to less than 15 million acres today (Wahlenberg 1949, Croker and Boyer 1975). It has become notorious as a difficult-to-establish species. Planting success has been erratic, with complete failures commonplace throughout the longleaf range. From 1973 through 1977, on the Black Creek Ranger District, Mississippi National Forest, overall yearly survival for 3,666 acres of planted longleaf ranged from 57 to 65 percent.

The average survival was 62 percent and was not considered adequate, principally because several plantations were considered failures each year. Our results were not as good as other results reported by Tom Croker and the T. R. Miller Company in Alabama, where over 80 percent survival was common for large seedlings planted within three days of lifting. To determine the reasons for our failures we decided to look at the variables of length of storage and size of seedlings as they affected survival.

METHODS

For testing we selected a 67 acre area of ridge top and side slopes with up to 12 percent slope. The soil was a fine sandy loam of the McLaurin series. Unfortunately the site was not as well prepared as we like for planting longleaf. Instead of shearing, raking, and deep discing, the area was only chopped and deep disced. As a result, 21 percent of the seedlings were misplanted, either too shallow or too deep.

Seedlings were lifted on November 29, January 19, February 4 and 10, and March 20. For each lifting date, seedlings were machine planted on four ¼ acre plots immediately and at about weekly intervals by a regular Forest Service crew.

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For the earliest lifting date, seedlings were stored for up to 8 weeks. Because of weather and an oversight, no seedlings from the January 19 lifting were planted for 2½ weeks.

Seedlings were taken from regular Ashe Nursery shipments. The packing procedure was to spray the seedlings with a Kaolin slurry, add a few handfuls of moss, and seal about 600 seedlings in a Kraft polyethylene lined bag. Bags were stacked with spacers in a cooler and kept at 34°F except for one day when the temperature went to 45°F.

From the 23,008 seedlings planted, 5 percent were checked in late May for survival, proper planting, root collar diameter (RCD), and cause of mortality if apparent. Any seedling with green needles was considered as alive. Only trees that were properly planted were used in the analyses. In addition, the 13 percent of the seedlings that died from silting in or washing out were excluded. For easier interpretation length of storage was grouped into 10-day interval classes.

RESULTS AND IMPLICATIONS

For successful longleaf pine plantations, only seedlings with a root collar diameter of 0.5 inch or larger should be used (Diagram 1). This size seedling can be stored for up to 3 weeks without a loss in survival. For seedlings that have a RCD of 0.6 inch or more, it appears that storage can be extended to 5 or 6 weeks longer. The reduced survival with storage trend is very obvious in the .4 and .5 classes and we anticipate that survival would drop off in the .6 class with extended storage also.

It appears marginal to plant .4 inch RCD seedlings. Although survival for seedlings stored up to 20 days was 63 percent, this is far below the 90 percent of the 0.5 inch RCD seedlings. It is also important to remember that we are dealing here with only properly planted seedlings. Small additional losses would normally occur because of misplanting. At best, it may be possible to tolerate a small percentage of these 0.4 inch RCD seedlings when mixed in with larger ones.

There is no doubt that seedlings 0.3 inch RCD or less should be culled. In this test, they made up 21 percent of the seedlings, compared with 30, 37, and 12 for the 0.4, 0.5 and 0.6 or more classes, respectively.

This study indicated that more attention needs to be given to size of longleaf pine seedlings and length of storage. Unlike Loblolly (Pinus taeda L.) and Slash (Pinus elliottii Engelm. Var. elliottii) pine seedlings (Williston 1974) a Longleaf seedling may look good when it gets to the field, but with extended storage there is apparently a physiological change that makes it less able to survive. From an operational standpoint, intensive culling to 0.5 inch RCD appears to be a better alternative than increasing planting density. In addition, seedlings should be stored no more than 3 weeks.

We recognize our conclusions are based on empirical evidence and may need to be refined. However, at the very least it is solid evidence of what happened under a variety of planting conditions and lifting dates. Even with these factors contributing to variation in survival, the message of seedling size and length of storage comes through clearly. We propose that this serve as a guide until refined by further testing.

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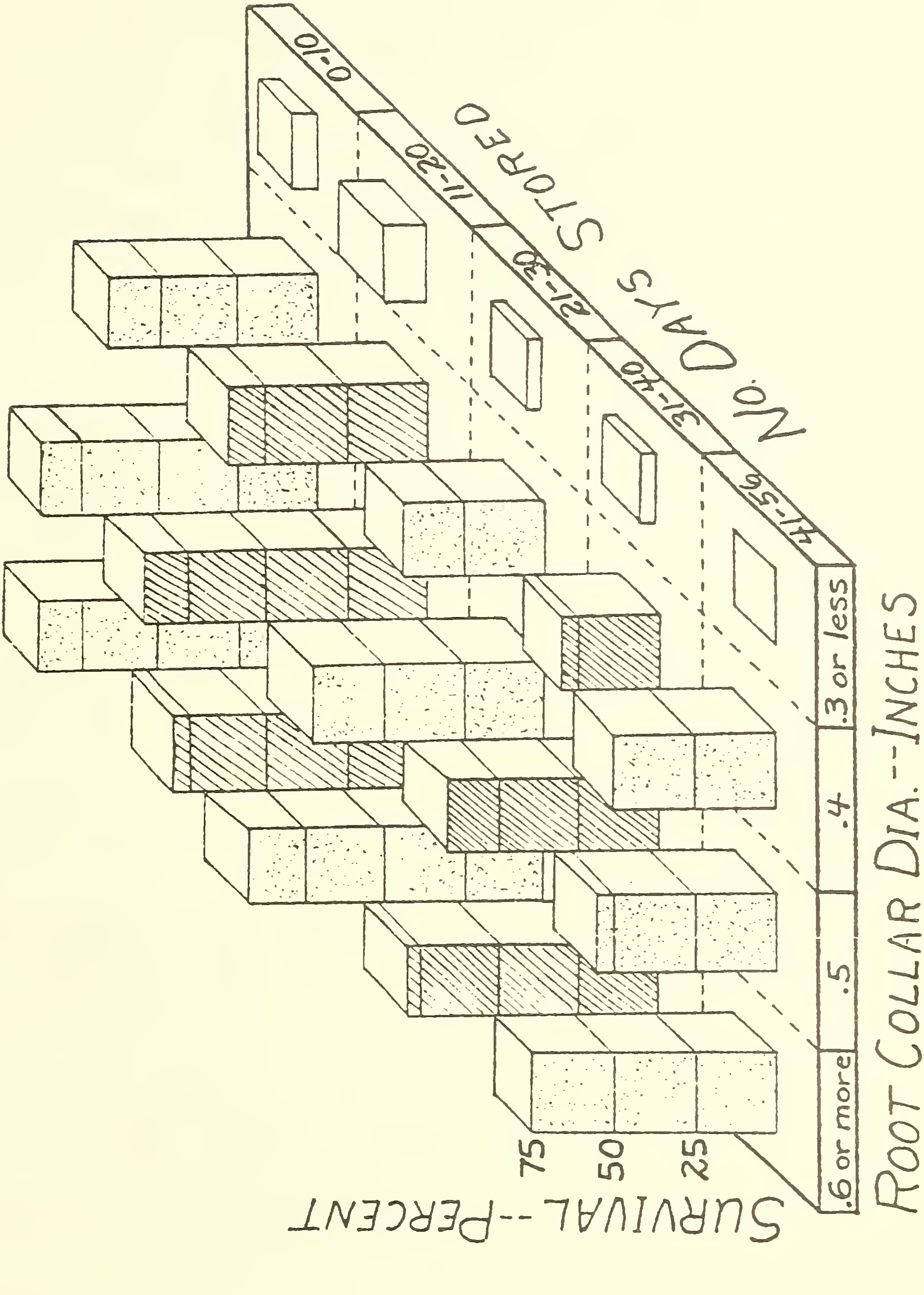
No. DAYS STORED
0-10
11-20
21-30
31-40
41-56
ROOT COLLAR DIA.--INCHES
.3 or less
.4
.5
.6 or more
SURVIVAL--PERCENT
75
50
25

VOLUME PRODUCTION OF THINNED NATURAL LONGLEAF

Robert M. Farrar, Jr. [1]

Abstract.--Equations are presented for predicting and projecting stand total and merchantable cubic foot volumes and basal area per acre for even-aged thinned stands of natural longleaf pine. Example predictions are given for merchantable cubic foot volumes and for a simulated thinning regime on site index 70.

Additional keywords: Pinus palustris, growth, yield

Longleaf pine stands once covered as much as 60 million acres from southern Virginia to East Texas (Wahlengerg 1946); present acreage probably stands at about 5 million (Farrar 1978). The reduction of longleaf pine was basically caused by stands being harvested without the establishment of adequate longleaf reproduction. Longleaf is reputedly a difficult species to regenerate, but modern silvicultural techniques have made regeneration of longleaf practical. Today, many people are considering regenerating this species because it resists fire, disease, and insects better than the other southern pines that cover much of its former range.

After regeneration, good forest management depends on comprehensive stand growth and yield information. This information is needed for nearly any silvicultural or management activity--from planning thinnings and scheduling harvests to financial analysis of management alternatives. At present, several sources of information on natural longleaf growth and yield are available. These include the "normal" yield tables (Forest Service 1976), "well-stocked" yield tables (Schumacher and Coile 1960), and reports on various thinning studies (e.g., Chapman 1951; Gaines 1951; Farrar 1968, 1974). However, none of these sources provides a comprehensive basis for predicting the production from stands thinned to various residual densities over a wide range of ages and site indices.

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To gain comprehensive information for thinned natural stands of longleaf, the Southern Station embarked on a cooperative regional longleaf growth study. This paper highlights results of the first 5-year growth period of the study.

Regional Longleaf Growth Study

The study consists of 175 permanent fifth-acre plots established on the lands of cooperators in southwest Georgia, north Florida, central and southern Alabama, and southern Mississippi. Plots were established to fill out a rectangular distribution of four age classes, five site index classes, and five residual density classes (Table 1).

Study plots are in pure, even-aged, natural longleaf pine stands that are free of insect, disease, wildfire, and other damage and are uniform in site quality and density. Plots were established during three different calendar years because of field work logistics and to include climatic variation. They are inventoried and thinned from below every 5 years to maintain their assigned densities. Most plots are prescription burned every 3 to 5 years for protection and vegetation control.

Table 1.--Distribution of 139 plots at beginning of 5-year growth period by site index, age, and residual basal area per acre.

SITE INDEX age 50	AGE	BASAL AREA PER ACRE (square feet)				
		≤ 45	46 to 75	76 to 105	106 to 135	≥ 136
(feet)	(years)	(number)				
46 to 55	11 to 30	3				
	31 to 50	1	2	3	2	
	51 to 70	1		1	1	1
	71 to 90	1	1	1	1	
56 to 65	11 to 30	9	2			
	31 to 50	2	2	2	3	1
	51 to 70	2	3	1	1	2
	71 to 90	1		1		
66 to 75	11 to 30	8	7		1	
	31 to 50	3	1	4	2	2
	51 to 70	2	4	5	5	1
	71 to 90	1	2	2		1
76 to 85	11 to 30	1	2	2	2	1
	31 to 50	1	2	2	2	3
	51 to 70	3	3	2	2	2
	71 to 90			1		
86 to 95	11 to 30					
	31 to 50	2	1			
	51 to 70	1	1		1	
	71 to 90					

Fifteen supplemental plots were established in a 9-year-old natural stand on an average site (site index 70) as a spacing experiment to enable conversion of density expressed as trees per acre at an early age to stand basal area per acre at a later age. Density varied from 300 to 1500 trees per acre in this spacing study. The results of this experiment through age 20 are included.

Analysis and Results

In analyzing the data, plots were excluded when catastrophic mortality had occurred among the upper crown classes. Any amount of mortality in the intermediate and suppressed crown classes was acceptable.

Analyses of the main study consisted of fitting equations to net stand volume and basal area data for 139 plots at the start and end of the growth period by least squares regression. Modified versions of the simultaneous growth and yield prediction models developed by Sullivan and Clutter (1972) for natural loblolly were used. Also, tree cubic-volume prediction functions and a site index function were developed by least squares regression as prerequisites to the growth and yield analyses. For the supplemental experiment, an iterative trees-per-acre survival function, similar to the one proposed by Hamilton (1974) was fitted along with a basal area function in terms of stand age and surviving trees per acre.

In all stand volume prediction equations the site index variable (S) is estimated by the following equation:

(1) $$S = (H)(10)^{\{f(50) - f(A)\}}$$

where S = site index (index age = 50 years) in ft. and $45 < S \leq 95$;

H = mean total height of dominant and codominant trees in ft.;

A = mean age of dominant stand in yrs., and $15 \leq A < 90$;

$f(50) = b_1/50 + b_2/(50)^2 + b_3/(50)^3 + b_4/(50)^4$

$f(A) = b_1/A + b_2/A^2 + b_3/A^3 + b_4/A^4$

$b_1 = -29.468$

$b_2 = 938.97$

$b_3 = -16102.0$

$b_4 = 88775.0.$

The basic stand volume and basal area prediction equations are as follows:

(2) $$TVI_1 = e^{\{2.6776 + 0.015287(S) - 21.909/A_1 + \ln(B_1)\}}$$

where A_1 = age at the start of the growth period;

B_1 = stand total basal area (sq. ft.) per acre at A_1, d.b.h. $\geq$ 0.6 in.;

e = base of natural logarithms:

ℓn = logarithm, base e;

TVI_1 = stand total cubic volume (cu. ft.,i.b.) per acre at A_1,d.b.h. $\geq$ 0.6 in., top d.o.b. = 0 in., stump = 0.2 ft.

Equation (2) accounts for about 99.5% of the variation about observed mean TVI_1.

(3) $$B_2 = e^{\{(A_1/A_2)\ell n(B_1) + 6.0594(1 - A_1/A_2)\}}$$

where A_2 = stand age at the end of the growth period and

B_2 = stand basal area per acre at A_2.

Equation (3) accounts for about 98.2% of the variation about observed mean B_2.

(4) $$TVI_2 = e^{\{2.6776 + 0.015287(S) - 21.909/A_2 + \ell n(B_2)\}}$$

where TVI_2 = stand total cubic volume (cu. ft.,i.b.) per acre at A_2.

TVI_2 is obtained simply by substituting A_2 for A_1 and B_2 for B_1 in equation (2). Equation (4) accounts for about 98.4% of the variation about mean observed TVI_2.

The merchantable stand cubic volume for pulpwood and larger trees is:

(5) $$VI4_1 = TVI_1/[1. + e^{\{2.623 + 316.77/S + 10201/((S)(B_1)) - 2.8248(\ell n(A_1)) - 3326.7(\ell n(A_1))/((S)(B_1))\}}]$$

where $VI4_1$ = stand merchantable cubic volume (cu. ft., i.b.) per acre at A_1, d.b.h. $\geq$ 3.6 in., top d.o.b. = 3 in., stump = 0.2 ft.

$VI4_2$, the volume at A_2, is obtained by substituting TVI_2, A_2 and B_2 in equation (5). Equation (5) accounts for about 99.5% and 98.5% of the variation about observed means for $VI4_1$ and $VI4_2$.

The merchantable stand cubic volume for sawtimber-sized trees is predicted by:

(6) $$VI10_1 = VI4_1/[1. + e^{\{2.9939 - 2.7845(\ell n(A_1)) + 1281.5/S - 217.67(\ell n(A_1))/S + 0.016017(B_1)\}}]$$

where $VI10_1$ = stand merchantable cubic volume (cu. ft., i.b.) per acre at A_1, d.b.h. $\geq$ 9.6 in., top d.o.b. = 7 in., stump = 0.2 ft.

Again, $VI10_2$ = the volume at A_2 and is obtained by substituting $VI4_2$, A_2, and B_2 in equation (6). Equation (6) accounts for about 92.3% and 93.2% of the variation about the means for $VI10_1$ and $VI10_2$.

Equations (2), (3), and (4) are the basic equations developed for total cubic volume growth and yield predictions for thinned natural longleaf stands. Merchantable cubic volume values are obtained as functions of TVI, A, S, and B. The system of equations can be used to estimate total and merchantable volumes for any stand with $A_1 \geq 15$ years but is probably better restricted to stands with $A_1 \geq 20$ years because site index is better estimated at older ages and merchantable volumes are more variable at young ages because of erratic ingrowth.

To use information on stands younger than 20 years for projection purposes, a system has been developed from the supplemental spacing experiment whereby the surviving trees per acre (TS) can be predicted annually for any age between 9 and 20 years and any initial density of 300 to 1500 trees per acre. Given an estimate of the surviving trees at age 20, an estimate can be made of the basal area at age 20 which is acceptable in the main growth and yield prediction system (equations 2 thru 6).

The survival function is:

(7) $$TS_{A+1} = (TS_A)/[1. + e^{\{-15.834 + 0.36197(A) + 0.0033710(TS_A)\}}]$$

where A = initial stand age in yrs., and $9 \leq A < 20$;

TS_A = surviving trees per acre at A, all living trees;

TS_{A+1} = surviving trees per acre at A + 1, all living trees.

Equation (7) accounts for about 98% of the variation about mean observed TS_{A+1} for a 10- year period. Note that solutions to equation (7) are iterative but a solution can be started at any age between 9 and 19 and need not always start at a fixed initial age.

The surviving basal area predictor is:

$$(8) \qquad SB = e^{\{6.8773 - 44.014/A - 44.72/TS - 3703.2/((A)(TS))\}}$$

where A = stand age in yrs. and $9 \leq A \leq 20$;

SB = surviving basal area (sq. ft.) per acre at age A and d.b.h. $\leq$ 0.6 in.;

TS = surviving trees per acre at age A, all living trees.

Equation (8) accounts for about 92% of the variation about mean observed SB.

PREDICTIONS AND UTILITY

An example of the types of predictions possible and an exercise in simulating one thinning schedule are presented to illustrate use of the equations. A calculator with exponents and logarithms is a minimum requirement for evaluating equations, but a programmable one with several storage registers is considerably more useful.

The survival function (equation 7) and basal area function (equation 8) for stands younger than 20 years are illustrated by Figures 1 and 2. For older stands on site index 70, an array of initial and projected basal areas generated by equation 3 are presented in Table 2. Initial and projected merchantable stand volumes corresponding to these basal areas and generated by equations 5 and 6 are

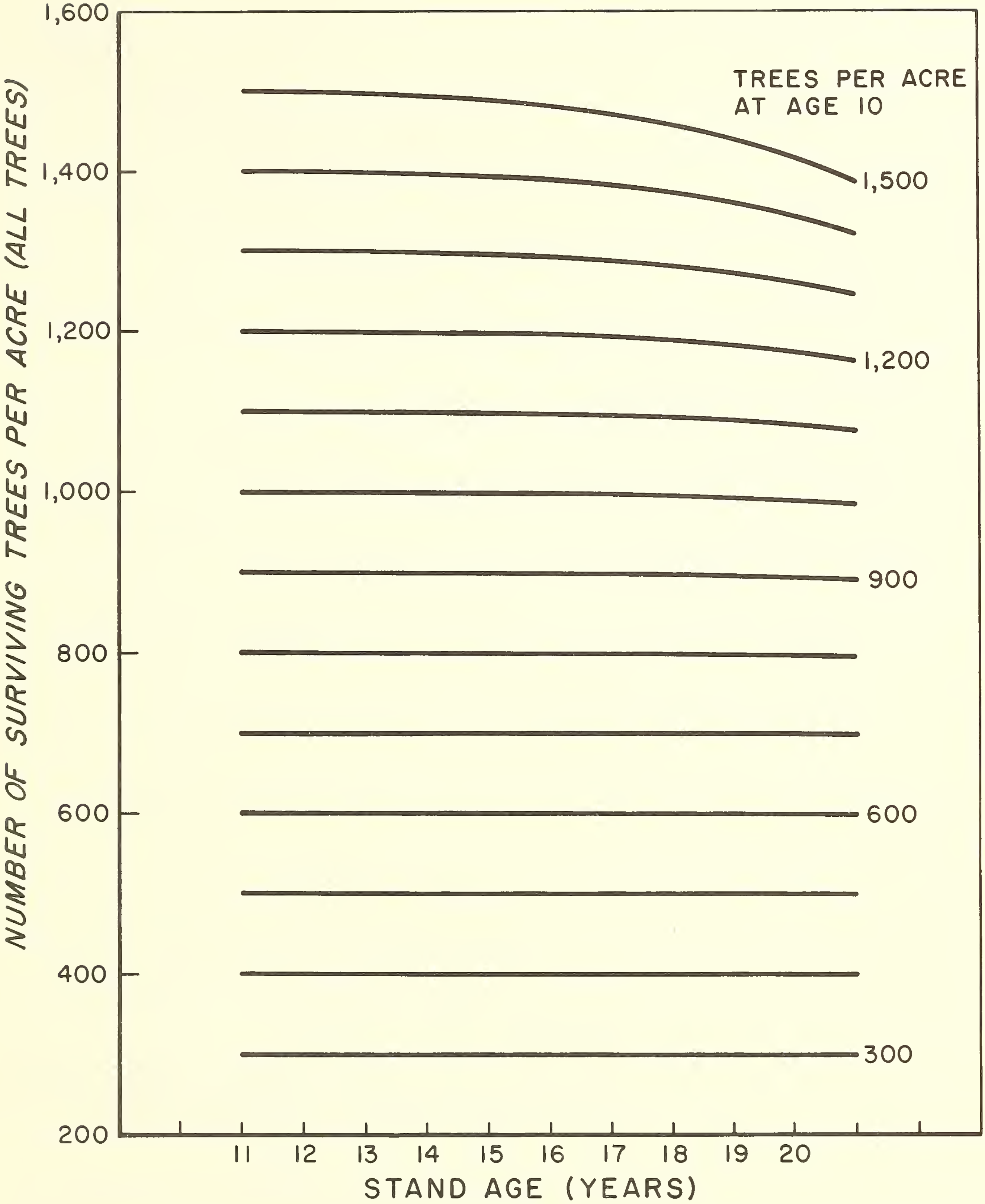

Figure 1.--Number of surviving trees per acre predicted by stand age and inital number of trees at age 10, site index = 70.

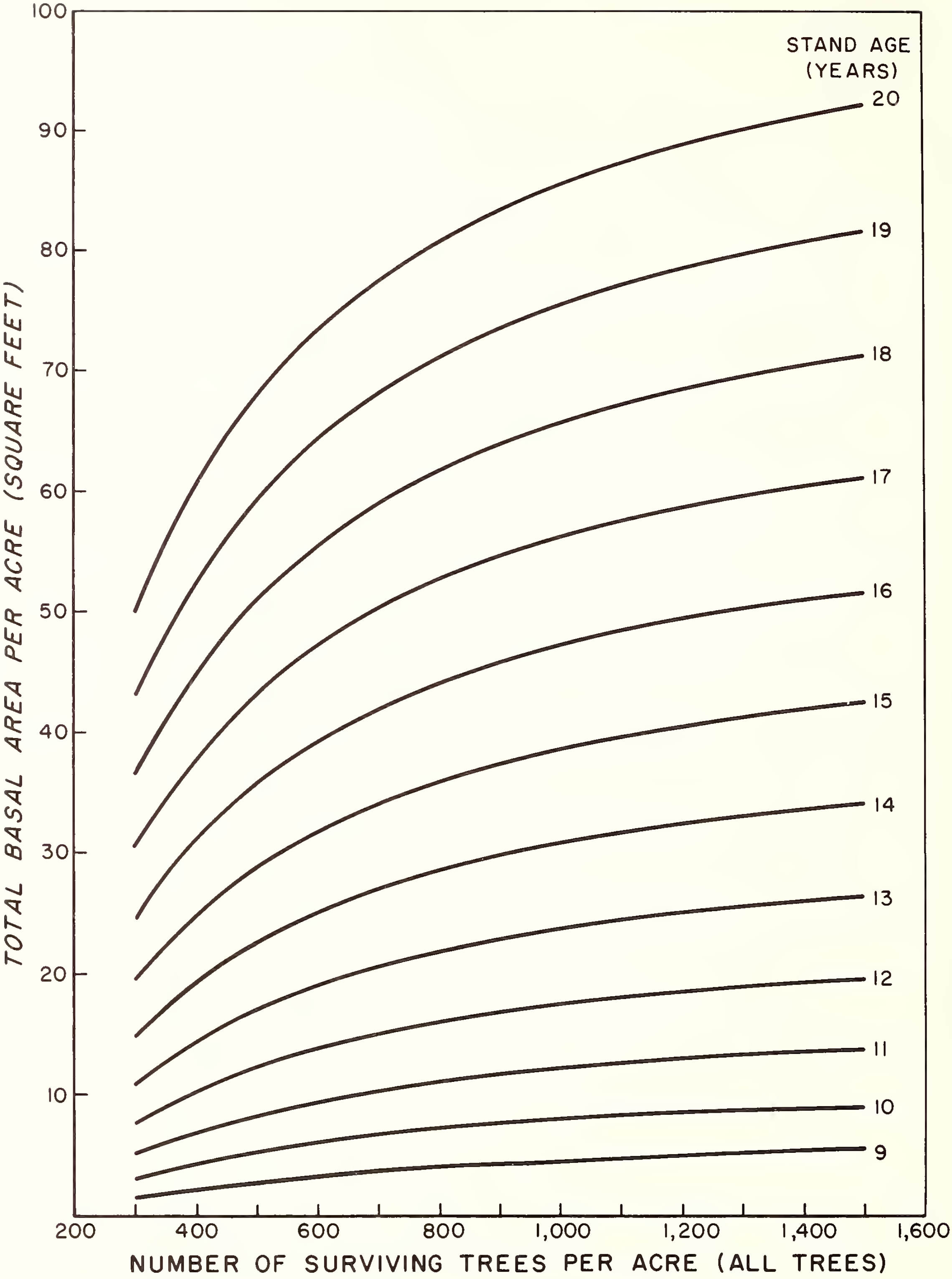

Figure 2.--Total basal area predicted by surviving trees per acre and stand age, site index = 70.

shown in Table 3. Additional computations can be made for total stand volume or for other combinations of initial and final age, site index, and basal area at initial age.

To illustrate use of the system of equations, assume that we have a 10-year-old stand of about 800 longleaf seedlings and saplings per acre. At age 20, the survival function (Fig. 1) predicts about 794 trees, which translates to about 80 sq. ft. of basal area at this age (Fig. 2). By referring to Table 3, we see that the predicted volume (VI4) for this age and basal area is 890 cu. ft. These basal areas and volume values are the starting point of the thinning simulation in Table 4.

In Table 4 we assume a thinning regime that leaves 40 sq. ft. of basal area at age 20, 60 sq. ft. at age 30, 80 sq. ft. at age 40, 60 sq. ft. at age 50, a shelterwood stand of 30 sq. ft. at age 55, and a removal cut at age 60. For convenience, consider only VI4. If we leave 40 sq. ft. of basal area and cut 40 sq. ft. at age 20, the volume left is 440 cu. ft. (from Table 3) and the volume cut is 450 cu. ft. (obtained by subtraction). Now let the stand grow for 10 years and thin it again at age 30 to leave 60 sq. ft. of basal area. A stand of 40 sq. ft. projected from age 20 to age 30 results in 88 sq. ft. (Table 2) and 1680 cu. ft. before the cut at age 30 (Table 3). The 1150 cu. ft. left at age 30 means removal of 530 cu. ft. (1680 - 1150). As before, we project the residual 60 sq. ft. of basal area from age 30 to 40 and obtain 98 sq. ft. (Table 2). The residual volume at age 30 projected to age 40 is 2340 cu. ft. (Table 3). We

Table 2.--Initial and projected stand basal areas, natural longleaf.
(sq. ft. per acre)

Proj. Stand Age (Yrs.)	Basal area/acre at age 20 (sq. ft.)										
	20		40		60		80		100	120	140
20	20		40		60		80		100		
30	56		88		116		140		162		
40	93		131		160		185		207		
50	126		166		195						
	Basal area/acre at age 30 (sq. ft.)										
	20		40		60		80		100	120	140
30	20		40		60		80		100	120	
40	43		72		98		122		144	165	
50	68		103		132		156		179	200	
60	93		131		160		185		207		
	Basal area/acre at age 40 (sq. ft.)										
	20		40		60		80		100	120	140
40	20		40		60		80		100	120	140
50	37		64		89		112		134	155	175
60	56		88		116		140		162	183	203
70	74		110		139		164		186	207	
	Basal area/acre at age 50 (sq. ft.)										
		30	40	50	60	70	80	90			
50		30	40	50	60	70	80	90			
55		38	50	61	72	83	93	104			
60		47	59	72	83	95	106	117			
65		55	69	82	94	106	118	129			
70		64	79	92	105	117	129	141			
	Basal area/acre at age 55 (sq. ft.)										
		30	40	50	60	70	80	90			
55		30	40	50	60	70	80	90			
60		37	49	60	71	81	92	102			
65		45	58	70	81	92	104	114			
70		53	66	79	91	103	115	126			
75		61	75	89	101	113	125	136			

Table 3.--Initial and projected stand volumes, natural longleaf, site index = 70.
(cubic feet, i.b., per acre)

Proj. Stand Age	Basal Area/Acre at Age 20 (sq. ft.)													
	20		40		60		80		100		120		140	
(Yrs.)	VI4 [1]	VI10 [2]	VI4	VI10	VI4	VI10	VI4	VI10	VI4	VI10	VI4	VI10	VI4	VI10
20	220	-	440	10	660	10	890	10	1110	10				
30	1070	110	1680	110	2200	90	2660	80	3080	60				
40	2210	580	3120	500	3810	410	4400	330	4910	260				
50	3390	1480	4470	1290	5250	1070								
	Basal Area/Acre at Age 30 (sq. ft.)													
	20		40		60		80		100		120		140	
30	390	70	770	100	1150	110	1530	110	1900	100	2280	90		
40	1040	450	1730	570	2340	570	2900	530	3420	460	3920	390		
50	1840	1220	2790	1470	3550	1470	4220	1350	4820	1200	5370	1030		
60	2710	2150	3820	2580	4680	2650	5400	2520	6040	2300				
	Basal Area/Acre at Age 40 (sq. ft.)													
	20		40		60		80		100		120		140	
40	490	260	960	430	1440	540	1910	580	2390	570	2860	530	3330	470
50	1000	760	1740	1170	2400	1400	3020	1480	3610	1460	4170	1360	4720	1220
60	1630	1420	2580	2080	3370	2450	4090	2630	4740	2640	5350	2530	5930	2350
70	2300	2130	3410	2990	4300	3520	5060	3810	5750	3910	6380	3860		
	Basal Area/Acre at Age 50 (sq. ft.)													
	30		40		50		60		70		80		90	
50	820	640	1090	820	1360	980	1630	1120	1890	1240	2160	1330	2430	1410
55	1080	920	1400	1150	1720	1360	2030	1550	2330	1700	2630	1830	2920	1930
60	1370	1220	1740	1510	2090	1770	2440	1990	2770	2180	3090	2340	3410	2470
65	1670	1530	2080	1880	2470	2180	2840	2440	3200	2660	3550	2850	3880	3010
70	1980	1860	2430	2250	2850	2580	3250	2880	3630	3140	3990	3360	4340	3540
	Basal Area/Acre at Age 55 (sq. ft.)													
	30		40		50		60		70		80		90	
55	850	730	1130	960	1420	1160	1700	1350	1980	1520	2260	1670	2540	1790
60	1100	990	1430	1270	1750	1520	2070	1750	2380	1960	2690	2140	3000	2300
65	1360	1270	1740	1590	2100	1890	2450	2160	2790	2400	3120	2610	3440	2800
70	1640	1550	2060	1920	2450	2260	2820	2560	3190	2840	3540	3080	3880	3290
75	1930	1850	2380	2260	2800	2630	3200	2960	3580	3260	3950	3530	4300	3770

[1] VI4 = Stand merchantable cubic volume (cu. ft., i.b.) per acre, d.b.h. ≥ 3.6 in., top d.o.b. = 3 in., stump = 0.2 ft.

[2] VI10 = Stand merchantable cubic volume (cu. ft., i.b.) per acre, d.b.h. ≥ 9.6 in., top d.o.b. = 7 in., stump = 0.2 ft.

Table 4.--A thinning regime simulation in a natural longleaf stand, SI_{50} = 70.

	Before Cut			After Cut			Cut		
Age	B [1]	VI4 [2]	VI10 [3]	B	VI4	VI10	B	VI4	VI10
Yrs.	sq.ft.	cu.ft.		sq.ft.	cu.ft.		sq.ft.	cu.ft.	
20	80	890	10	40	440	10	40	450	0
30	88	1680	110	60	1150	110	28	530	0
40	98	2340	570	80	1910	580	18	430	-
50	112	3020	1480	60	1630	1120	52	1390	360
55	72	2030	1550	30	850	730	42	1180	820
60	37	1100	990	0	0	0	37	1100	990
								5080	2170

[1] B = Stand basal area (sq. ft.) per acre, d.b.h. $\geq$ 0.6 in.

[2] VI4 = Stand merchantable cubic volume (cu. ft., i.b.) per acre, d.b.h. $\geq$ 3.6 in., top d.o.b. = 3 in., stump = 0.2 ft.

[3] VI10= Stand merchantable cubic volume (cu. ft., i.b.) per acre, d.b.h. $\geq$ 9.6 in., top d.o.b. = 7 in., stump = 0.2 ft.

leave 80 sq. ft. of basal area at age 40. This corresponds to 1910 cu. ft. of residual volume (Table 3) and a removal of 430 cu. ft. (2340 - 1910). The procedure is repeated in similar fashion for the shelterwood preparatory, seed, and removal cuts. The predicted volumes produced by this simulation are 5080 cu. ft. (VI4) per acre or 2170 cu. ft. (VI10) per acre. (Note that VI4 volumes are not in addition to VI10 cu. ft. volumes but are instead of VI10 volumes.) These production figures yield mean annual increment values of 85 cu. ft./acre and 36 cu. ft./acre, respectively.

The simulation possibilities with the system of equations are almost unlimited, and, particularly if one has access to a large computer, relatively easy. Thus, a wide variety of stand management options can be simulated. However, the following should be kept in mind:

(1) The system is based only on the first 5 years of growth and is a first approximation to the growth and yield of thinned natural longleaf. Inclusion of additional periods as data become available may improve the predictions.

(2) Long-term projections for unthinned stands may be inaccurate. The system is based essentially on thinned stands, one 5-year growth period, and excludes long-term mortality. The net growth recorded during the relatively short growth period may not reflect the mortality that might occur during longer periods. The system probably will not reliably project

estimates for unthinned stands for more than 20 to 30 years at best unless the user develops an adjustment for long-term mortality. The basal area and volume projections from present equations tend to become unrealistically large if performed for too long an unthinned period.

(3) The equations probably depict about the best performance we can expect from thinned natural longleaf stands. The basal area and volume predictions and projections are for uniform stand conditions and essentially incorporate only the effects of mortality attributed to suppression. Also, all thinning was from below with a minor amount of improvement cutting in upper crown classes and deleterious environmental effects were minimized.

(4) A minor interpretation problem sometimes arises when simulating sawtimber cubic volume (VI10) growth and yield at relatively young ages under thinning regimes. The projected volume for a relatively high projected basal area before cut can be less than the stand volume predicted for a lower basal area after cut; the difference depends on the stand age and residual basal area chosen (see Table 4). This anomaly apparently occurs because VI10 predictions reflect the effect of sudden sawtimber ingrowth in young stands. The ingrowth effect seems strongly related to basal area such that VI10 peaks at medium densities in young stands and peaks at increasingly higher densities as age increases. In a thinning simulation

exercise, the net effect can be that at a given age less sawtimber volume is predicted for an initial basal area than is predicted for a lower residual basal area. However, the difference is generally small and the problem disappears as stand age increases. The problem can be ignored by assuming that if the stand had a certain sawtimber cubic volume predicted at a given age before cutting, it should have no more than this volume in the residual stand.

Although it has limitation, the system of equations should be useful to those planning the management and harvest of natural longleaf stands. It permits estimates of current and future stand volumes for a considerable array of stand conditions and allows simulation of a wide variety of thinning regimes and rotation lengths of potential interest to longleaf timber-land owners.

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QUESTIONS AND ANSWERS

Harry Murphy:	What are yield differences between loblolly and longleaf - same sites, same site index - at ages 20, 30, and 50 years?
Response:	Such information for the same physical soil area is virtually non-existent as far as I know except for plantations less than 20 years old (contact Gene Shoulders, SFES, Alexandria, LA). Our best estimate of site index is from the stand occupying the site using a suitable site index function and we usually do not have site index predictions for other species for that site. Good multiple species site quality information for our various sites is obviously highly desirable but it will have to await much more comparative outplantings or, preferably, intensive investigation of the soil, climatic, biotic, physiographic and other factors influencing site productivity. However, we can make a standing total volume comparison via growth and yield prediction systems for natural stands if we assume the same age, dominant stand height, and basal area for longleaf and loblolly stands. Such a comparison is presented below for longleaf site index 70 assuming the these equations for longleaf and the Sullivan and Clutter (1972) least squares equations and the Coile and Schumacher (1960) site index function for loblolly.

Loblolly					Longleaf			
Age	Dom. Ht.	Site index	BA	TVI	Dom. Ht.	Site index	BA	TVI
yrs.	ft.	ft.	ft^2	ft^3, i.b.	ft.	ft.	ft^2	ft^3, i.b.
20	39	61	40	490	39	70	40	570
20	39	61	60	730	39	70	60	850
20	39	61	80	960	39	70	80	1130
30	56	68	40	770	56	70	40	820
30	56	68	60	1150	56	70	60	1230
30	56	68	80	1520	56	70	80	1640
30	56	68	100	1890	56	70	100	2040
30	56	68	120	2270	56	70	120	2450
50	70	70	40	1050	70	70	40	1090
50	70	70	60	1560	70	70	60	1640
50	70	70	80	2070	70	70	80	2190
50	70	70	100	2570	70	70	100	2740
50	70	70	120	3080	70	70	120	3280
50	70	70	140	3580	70	70	140	3830

We observe a 40 to 250 cubic foot difference in standing total volume in favor of the longleaf and this holds similarly for longleaf site index 50 and 90. Fundamentally, the difference is due to differences between the prediction equations which may, if true, be interpreted biologically as differences in tree form - the longleaf may have trees with better form. There may be other reasons also, i.e., differences in diameter and height distributions. However, from a practical standpoint, considering the variability of natural stands and in absence of any statistical tests for significance the predictions may be conservatively considered equal. The different site indices predicted for loblolly and longleaf for the same height at the younger ages reflect differences in the site index curves used for the two species. This evaluation in no way suggests similar volumes for the two species on any given land area but simply indicates a similarity in standing volume if the stand age, dominant height and basal areas are the same.

Harry Murphy: Is there a difference in stumpage price between loblolly, slash and longleaf in the longleaf natural range?

Response: John White - In south Mississippi longleaf has sold for $40 more per mbf Scribner.

Conrad Franz: When does the mean annual increment (MAI) curve cross the annual increment (CAI) curve in terms of board feet and cubic foot volume on site index 70, 80, and 90 lands?

Response: This can vary somewhat with the thinning regime employed so one would do well to evaluate various proposed regimes using the system of equations in the text to see the effects but here only one generally proposed regime will be evaluated: thinning from below every 5 years from age 25 through 75 to leave 60% of the "normal" basal areas given in Table 69 of M.P. 50 (FS 1976). Also the following assumptions are used: 1) five-year periodic annual increment (PAI) suitably approximates CAI, 2) the stand initially has 60% of "normal" basal area at age 20 and we simply end the exercise at age 80 without employing any shelterwood cuts, 3) the cubic volume in trees 10" d.b.h. and larger is substituted for board foot volume, 4) all previously cut volumes are added to the before-cut volume at a given age for the purpose of computing MAI, 5) PAI is the difference between leave volume at age A and projected volume at age A + 5 divided by 5.

The results of this exercise were:

For cubic volume 4"+, it appears that PAI is equal to MAI at age 60 for SI 70 and 80 and at age 55 for SI 90 for this thinning regime. For cubic volume 10"+, it appears that MAI continues to increase through age 80 (but the curve becomes flattened) and PAI remains above MAI through age 75 indicating that MAI for the sawtimber component does not maximize before age 80 for these three site indices and this thinning regime. Also, the highest PAI for cubic volume 4"+ apparently occurs in the first period between ages 20 and 25 (it may in fact peak earlier) and the peak PAI for cubic volume 10"+ occurs between ages 50 and 55 for SI 70, between 45 and 50 for SI 80 and between 40 and 45 for SI 90.

In the exercise in Table 4 in the text the PAI for volume 4"+ appears to equal the MAI at about age 50 and the PAI for volume 10"+ remains above the MAI throughout the 60 year rotation with a peak PAI occurring between age 40 and 50.

Jim Thorson: What is the maximum age one can thin longleaf?

Response: Who really knows? Longleaf is probably the longest-lived of the southern pines and appears to remain vigorous to relatively old ages. In the above mentioned exercise of thinning to leave 60% of "normal" basal area on site index 70, the predictions were that about 280 cubic feet 4"+ would be cut at age 75 and the growth from 75 to 80 would be about 360 cubic feet.

John White: At what age does thinning become non-economical, i.e., sawtimber growth doesn't increase over that cut?

Response: This would depend upon what is considered an economical volume value for growth or cut, the site index and the thinning regime employed. If we say that 100 or 200 cubic feet 10"+ is the minimum operable cut then very few stands will be operable for sawtimber cuts before age 30 on the better sites and perhaps age 40 or 50 on the poorer sites according to our predictions - unless cut from above. At older ages the cut at a given age may exceed the growth for the next 5 years but that growth might still be acceptable. For illustration see Table 4 in the text. At age 55 we cut 820 cubic feet 10"+

but the growth from age 55 to 60 on 30 basal area is 260 cubic feet--much less than 820 but undoubtedly acceptable. In the above exercise of thinning to 60% of "normal" basal area from age 25 through 75, the cuts at age 75 were always less than the growth from age 75 to 80. One should use the system of equations in the text to similarly evaluate a number of optional regimes.

Jim Thorson: With a rotation of 80 years, what is the desired basal area for the final harvest for longleaf on site index 70?

Response: According to Tom Croker if shelterwood regeneration is employed the prep cut should leave no more than about 70 square feet at age 70 and the seed cut should leave between 20 and 25 square feet at age 75. This should result in 24 to 30 square feet in the final harvest at age 80. Whether shelterwood is employed or not, the density regime depends on the product and other objectives of the landowner. Thinning just enough to capture anticipated merchantable mortality should maximize cubic volume production if that is the objective whereas thinning according to some medium density regime (i.e., 60% "normal") might be better for multiple-product production, multiple use, and better income flow objectives. If maximum size per tree is desired then early and repeated thinning is required to leave a basal area that does not quite occupy the site.

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PREDICTED GROWTH OF LONGLEAF PINE PLANTED ON CUTOVER FOREST SITES IN THE WEST GULF

Richard E. Lohrey[1]

Abstract.--Basal area, total cubic volumes, and sawlog volumes are predicted from stand age, site index, and initial basal area. Estimates are based on data from 163 permanent plots in central Louisiana and east Texas. Volumes are probably conservative because stands planted recently generally had better survival and growth than older stands.

Additional keywords: *Pinus palustris*, total volumes, sawlog volumes.

Longleaf pine (*Pinus palustris* Mill.) won fame as a source of high-quality lumber, not for fast growth or high volumes per acre. Although it has slower juvenile growth than other southern pines, longleaf has several desirable characteristics. Trees are usually straight, well-formed, and suitable for high-valued products such as poles, piles, and structural timbers. Moreover, longleaf is the easiest of the southern pines to regenerate by direct seeding and is quite fire resistant even in the seedling stage.

There is little information on sawlog volumes in longleaf pine plantations. Wakeley (1969) reported up to 3,528 bd. ft. per acre at age 30 years in stands near Bogalusa, Louisiana. The stands had been planted at spacings ranging from 5- by 5 to 10- by 10-feet; none had been thinned.

Ross (1942) described a small longleaf pine stand established on an old field by spot seeding at 10-foot intervals in furrows plowed 10 feet apart. At age 40 years, he estimated volume of the 1.15-acre unthinned stand was 15,652 bd. ft. per acre in trees 8 inches d.b.h. and larger.

This paper attempts to predict what volumes might be expected, based on results from three studies in longleaf pine plantations. All were established on cutover forest sites in Louisiana and Texas. Throughout the paper, plantation age is age from planting and site indices have base age 25 years.

METHODS

In the first study, trees were planted at four square spacings 4.3, 5.2, 6.2, and 13.1 feet, equivalent to densities of 2,500, 1,600, 1,150, and 250 trees per acre, respectively. Sixteen plots were planted at each spacing so different thinning treatments could be tested when the pines reached merchantable size.

The stand was burned by prescription at age 3 and at 3-year intervals thereafter until age 15 to control brown-spot needle disease (*Scirrhia acicola* [Dearn.] Siggers). Burning doubled the proportion of survivors in height growth at age 11 years, compared to an adjacent unburned stand (Wakeley and Muntz 1947). At age 20 years, stocking ranged from 78 trees per acre at the lowest planting rate to 519 trees per acre at the highest rate. Site index varied from 33 to 60.

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Plots in three treatments were thinned to residual densities of 60, 80, or 100 square feet of basal area per acre at age 20 and every 5 years thereafter. The fourth treatment left a maximum of 100 merchantable-sized crop trees per acre at age 20 with no subsequent intermediate cuts. These crop trees had been pruned to 17 feet at age 16 years in order to produce high-quality wood on trees with large diameters at an early age.

The second study, established in 24- and 25-year-old plantations, tested residual densities from 40 to 140 square feet of basal area per acre plus unthinned checks. Both stands had been planted at 6- by 6-foot spacing. Square, 1/4-acre plots averaged 582 trees with 112 square feet of basal area per acre before initial thinning. Densities on individual plots ranged from 368 to 868 trees and 87 to 135 square feet of basal area per acre. Site index ranged from 49 to 62.

In these first two studies thinning was essentially from below, with some but not all submerchantable trees being cut. All plots were reinventoried and rethinned at 5-year intervals after they were established. The few that had not reached their assigned basal area densities were not cut until the next regularly scheduled thinning.

The third study was initiated to obtain a wide range of sites and ages. Plots were established in stands 16 to 38 years old that showed no evidence of severe insect or disease damage. Most had been burned by prescription. Hardwood understories were present in a few plots, their extent depending upon the frequency and effectiveness of prescribed fires.

One to 12 permanent rectangular plots 1/10 to 1/4 acre in area were established in each of nine plantations. Planting densities ranged from 250 to 2,500 trees per acre. The number of trees surviving when plots were established varied from 71 to 1,550, but only 11 had more than 500 trees and only six had more than 1,000 trees per acre. Basal area densities ranged from 55 to 190 square feet per acre, with 12 plots exceeding 150 square feet per acre. Site indices were as low as 41, but 41 percent (24 of 58) were 60 or higher and the maximum was 68. None of these plots was thinned and all were reinventoried after 5 years.

The same measurement methods and procedures were used on all plots. The diameters at 4.5 feet (d.b.h.) of all trees 0.6 inch or larger were measured with a steel tape to the nearest 0.1 inch. Volumes of sample trees were determined by height accumulation (Grosenbaugh 1954). The sample trees were selected at random and in proportion to the number of trees in each 1-inch diameter class. Plot volumes were determined by multiplying the total basal area by the volume-basal area ratio defined by sample trees. Site indices were determined from equations based on data from second-growth natural stands (Farrar 1973).

The regression analysis used a system proposed by Clutter (1963) and later refined by Sullivan and Clutter (1972). Equations predict basal area and volume at some future age when site index, initial age, and initial basal area are given. All 457 observations (Table 1) were used to determine equations for future basal area and cubic volume. The sawlog analysis used the 288 observations that had board-foot volumes at the beginning of a measurement period.

Table 1.--Distribution of observations in longleaf pine plantations by initial age, site index, and basal area per acre

Initial age	Site index (feet)[1/]							
	≤ 39	40-44	45-49	50-54	55-59	60-64	≥ 65	Total
Years	Number							
≤ 22	11	32	31	33	29	11	8	155
23-27	2	12	20	40	29	4	5	112
28-32	0	10	28	39	25	3	0	105
33-37	0	3	24	37	4	0	0	68
38-42	0	0	1	14	2	0	0	17
Total	13	57	104	163	89	18	13	457

Initial age	Basal area (sq. ft. per acre)								
	≤ 29	30-49	50-69	70-89	90-109	110-129	130-149	≥ 150	Total
Years	Number								
≤ 22	53	32	33	17	6	3	3	8	155
23-27	8	21	27	21	19	16	0	0	112
28-32	2	15	34	20	17	10	7	0	105
33-37	0	7	19	23	14	2	1	2	68
38-42	0	0	0	3	6	3	3	2	17
Total	63	75	113	84	62	34	14	12	457

Site index[1/]	Basal area (sq. ft. per acre)								
	≤ 29	30-49	50-69	70-89	90-109	110-129	130-149	≥ 150	Total
Feet	Number								
≤ 39	12	1	0	0	0	0	0	0	13
40-44	33	15	8	1	0	0	0	0	57
45-49	13	27	41	18	4	1	0	0	104
50-54	5	24	35	46	35	12	5	1	163
55-59	0	7	28	12	20	13	6	3	89
60-64	0	1	1	5	0	5	3	3	18
> 65	0	0	0	2	3	3	0	5	13
Total	63	75	113	84	62	34	14	12	457

[1/] Base age 25. Corresponding values for base age 50 range from 52 to 107.

Equations are:

Projected basal area

$$\hat{B}_2 = \text{EXP}\ [(A_1/A_2)\ (\ln B_1) + 5.999450356\ (1.-A_1/A_2) -0.003138857(S)(1.-A_1/A_2)] \quad (1)$$

Estimated cubic volume

$$\hat{V}_{(c)} = \text{EXP}\ [3.0552605 + 0.013148109\ (S) -14.341899\ (1/A) + 1.0292124(\ln B)] \quad (2)$$

R^2 (log basis) = .94

Estimated sawlog volume

$$\hat{V}_{(s)} = \text{EXP}\ [10.866021 + 0.0059209319\ (S) -137.98345\ (1/A) + 0.31706237(\ln B)] \quad (3)$$

R^2 (log basis) = .73

In these equations:

$\hat{B}_2$ = projected basal area at age A_2, sq. ft./ac.

$\hat{V}(c)$ = estimated volume outside bark, entire stem of all trees, cu. ft. per ac.

$\hat{V}(s)$ = estimated sawlog volume in trees 9.6 inches d.b.h. and larger to an 8 inch top d.o.b. by Int. 1/4-inch rule, bd. ft. per ac.

A_1 = initial age from planting, years

A_2 = projection age

B_1 = basal area of all trees, sq. ft. per ac., at age A_1

B_2 = basal area at age A_2

S = site index, base age 25 years

RESULTS AND DISCUSSION

Projected basal area was inversely related to site index but the effect was minimal (Table 2). If basal area is predicted for an average site, the estimate can probably be used on all sites with results accurate enough for most forest management purposes.

From age 20 to 25 years, basal area growth was most rapid in stands with initial densities of 100 sq. ft./ac. or more. After age 30, growth was usually best in stands with 130 to 150 sq. ft./ac. Competition and mortality apparently limited basal area increment at densities above 150 sq. ft.

Projected total cubic volume, determined from equation (2), was directly related to basal area (Table 3). Volumes observed were comparable to those for natural longleaf stands of similar site quality and density, but less than those for other southern pines (USDA Forest Service 1929).

Sawlog volumes, obtained from equation (3) increased more rapidly with age than with basal area or site, particularly at older ages (Table 4). Age, of course, influences sawtimber volumes greatly because older trees have larger diameters. According to these estimates, board-foot volumes may be increased 4,000 bd. ft. per acre by delaying harvest 5 years.

Considering differences in utilization limits and log rules, yields in this study compare favorably with published estimates for fully stocked natural stands. A normal yield table for 40-year-old second-growth natural stands of longleaf pine on site index 51 (base age 25) shows 17,000 bd. ft. per acre in trees 7 inches d.b.h. and larger by the International 1/8-inch log rule (U.S. Dept. Agric. 1929).

Chapman (1951) reported yields at 35 years ranged from 10,644 to 11,653 bd. ft. (Int. 1/4-inch rule) per acre in thinned plots and 9,551 to 14,167 bd. ft. per acre in unthinned checks. At age 36, mean annual increment (MAI) averaged 330 bd. ft. per acre in thinned plots and 344 bd. ft. per acre in checks (Chapman 1953). These MAI figures represent yields of 11,862 and 12,366 bd. ft. per acre for thinned and check plots, respectively. Yields are for cutover land near Urania, Louisiana, with a site index of 51 (base age 25). They include volumes for trees in the 6-inch and larger diameter classes.

Unthinned natural second-growth longleaf pine stands of site index 52 (base age 25) on the McNeill Experimental Forest in Mississippi averaged 8,000 bd. ft. (Int. 1/4-inch rule) per acre at age 35 years (Smith 1950). The plots averaged 9,046 bd. ft. per acre before thinning at age 37 and 11,006 at age 42 years. Gross yield was 11,677 bd. ft. per acre at age 42 years. Periodic annual increment from ages 37 to 42 years exceeded 500 bd. ft. per acre per year (Smith 1955).

Table 2.--Projected basal area per acre for longleaf pine plantations of given site index, age, and basal area at age 20 years[1]

Basal area, age 20	Basal area at age 25	30	35	40	45	50
			Sq. ft. per acre			
			SITE INDEX 40[2]			
20	35	52	69	84	99	112
40	62	83	102	119	135	148
60	86	109	129	146	161	175
80	108	132	152	169	183	196
100	129	153	172	189	202	214
120	149	172	191	207	219	230
140	169	191	209	223	235	245
			SITE INDEX 50[2]			
20	35	52	68	83	97	110
40	62	82	101	117	132	146
60	85	107	127	144	158	171
80	107	130	150	166	180	192
100	128	151	170	186	199	210
120	148	171	189	203	216	226
140	168	189	206	220	231	240
			SITE INDEX 60[2]			
20	35	51	67	82	96	108
40	61	81	99	116	130	143
60	85	106	125	142	156	168
80	106	129	148	163	177	189
100	127	149	168	183	195	206
120	147	169	186	200	212	222
140	167	187	203	216	227	236

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[1] Projected basal area determined from equation (1).

[2] Corresponding values for base age 50 are 63, 79, and 94 feet for sites 40, 50, and 60, respectively.

Table 3.--Estimated total cubic volume per acre for longleaf pine plantations of given site index, age, and basal area [1]

Age	Basal area, sq. ft. per acre						
	40	60	80	100	120	140	160
Years	Cubic feet o.b.						
SITE INDEX 40[2]							
20	782	1,187	1,596	2,008	2,423	2,840	3,258
25	903	1,370	1,842	2,318	2,797	3,277	3,760
30	993	1,508	2,027	2,551	3,077	3,606	4,138
35	1,064	1,614	2,171	2,731	3,295	3,861	4,430
40	1,119	1,699	2,285	2,875	3,468	4,064	4,663
45	1,165	1,768	2,378	2,991	3,609	4,229	4,852
SITE INDEX 50[2]							
20	892	1,354	1,821	2,291	2,764	3,240	3,717
25	1,030	1,563	2,102	2,645	3,191	3,739	4,290
30	1,133	1,720	2,313	2,910	3,511	4,114	4,721
35	1,213	1,842	2,476	3,116	3,759	4,405	5,054
40	1,277	1,939	2,607	3,280	3,956	4,637	5,320
45	1,329	2,017	2,713	3,413	4,117	4,825	5,536
SITE INDEX 60[2]							
20	1,018	1,545	2,078	2,614	3,154	3,696	4,240
25	1,175	1,784	2,398	3,017	3,640	4,266	4,895
30	1,293	1,963	2,639	3,320	4,005	4,694	5,386
35	1,384	2,101	2,825	3,555	4,289	5,026	5,766
40	1,457	2,212	2,974	3,742	4,514	5,290	6,069
45	1,516	2,303	3,095	3,894	4,697	5,505	6,316

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[1] Total cubic volume determined from equation (2).

[2] Corresponding values for base age 50 are 63, 79, and 94 feet for sites 40, 50, and 60, respectively.

Table 4.--Estimated sawlog volume per acre for longleaf pine plantations of given site index, age, and basal area [1]

Age	Basal area, sq. ft. per acre						
	40	60	80	100	120	140	160
Years	Board feet, Int. 1/4-inch						
SITE INDEX 40[2]							
20	216	245	269	288	305	321	335
25	857	974	1,067	1,146	1,214	1,275	1,330
30	2,150	2,444	2,678	2,874	3,045	3,198	3,336
35	4,147	4,716	5,166	5,545	5,875	6,169	6,436
40	6,788	7,719	8,456	9,076	9,616	10,098	10,535
45	9,958	11,324	12,406	13,316	14,108	14,815	15,455
SITE INDEX 50[2]							
20	229	260	285	306	324	340	355
25	909	1,034	1,132	1,215	1,288	1,352	1,411
30	2,281	2,594	2,841	3,050	3,231	3,393	3,540
35	4,400	5,003	5,481	5,883	6,233	6,545	6,829
40	7,202	8,190	8,912	9,630	10,203	10,714	11,177
45	10,566	12,015	13,163	14,128	14,968	15,718	16,398
SITE INDEX 60[2]							
20	243	276	302	324	344	361	377
25	964	1,097	1,201	1,290	1,366	1,435	1,497
30	2,420	2,752	3,015	3,236	3,428	3,600	3,755
35	4,668	5,308	5,815	6,242	6,613	6,944	7,245
40	7,641	8,689	9,519	10,217	10,825	11,367	11,859
45	11,210	12,748	13,966	14,989	15,882	16,677	17,398

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[1] Sawlog volume yields determined from equation (3).

[2] Corresponding values for base age 50 are 63, 79, and 94 feet for sites 40, 50, and 60, respectively.

Volumes given in tables 3 and 4 are generally low compared to other species. They tend to confirm the general impression held by many foresters that longleaf pine is a slow-growing species. However, it need not always be so. Some observations made in the course of this study are worth noting.

First, most plots used in this study were in stands established in the 1930's and 40's. Hopefully, many nursery, site preparation, planting, and plantation management practices have improved since that time.

Second, the highest basal area observed, 190 sq. ft. per acre, was in a 17-year-old plantation, although unthinned stands up to age 38 were measured. The stand was established on a well-prepared site to test various nursery practices. Competition and disease control were intensive for several years. The four plots established at age 17 years averaged 178 sq. ft. of basal area and 4,436 cu. ft. o.b. per acre. Five years later, at age 22, the unthinned plots averaged 201 sq. ft. of basal area and 5,743 cu. ft. per acre. Merchantable volume in trees 3.6 inches and larger to a 4-inch top d.o.b. was 4,700 cu. ft. o.b./ac. (about 52 cords) at age 22 years.

Four more plots were established in a 20-year-old plantation. The stand was machine planted, heavily grazed by cattle, and burned frequently. Initially, these four plots averaged 158 sq. ft. of basal area and 4,222 cu. ft. o.b. per acre. Five years later, at age 25, they averaged 187 sq. ft. of basal area and 5,940 total cu. ft. o.b. per acre. Merchantable volume averaged 5,320 cu. ft., almost 60 cords, per acre at age 25 years.

Why are these two stands so much better than the average longleaf plantation? Is it the site quality? Site index is about 65 in both areas, but soils are not much different than in adjacent stands with only average site indices. Were the trees from a superior seed source? Probably not. The small quantities of seed available from superior sources 25 years ago were reserved for tree improvement studies and not used in general planting programs.

The most likely answer is that these two stands happened to receive a good combination of nursery, planting, and management practices that minimized competition and controlled brown spot. Apparently, longleaf requires extra care--tender loving care perhaps--not needed by other species.

Several stands show that the growth potential of longleaf pine is good. Our hundreds of plots and statistical analyses show our past management practices have not reached or captured that potential except occasionally by chance. We will never learn how fast longleaf pine can grow until we find out what conditions it prefers and then provide them. I believe longleaf may be a Cinderella species. When we learn how to establish and manage it properly, foresters may prefer longleaf pine for some objectives over other species.

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QUESTION AND ANSWER

Q--What is the optimum basal area to manage for when trying to optimize for high grade material such as poles?

A--On good sites carry at least 100 square feet through age 30 then thin back to 70 square feet.

Q--Can site index for longleaf be predicted from site index for loblolly or slash?

A--This information is not readily available. Gene Shoulder's species-site suitability now has height growth data for loblolly, longleaf and slash pine planted adjacent to one another at more than 100 locations through age 20. If you really want to dig, obtain Doug McClurkin's amd Bob Zahner's doctoral theses from the Duke University Library on the site index of longleaf and loblolly in the West Gulf. Their data was collected from adjacent stands where available.

Responses prepared by H. L. Williston

LONGLEAF PINE--A GOOD CANDIDATE FOR GENETIC IMPROVEMENT

Calvin F. Bey[1]

INTRODUCTION

Longleaf pine (Pinus palustris Mill.) occurs over a wide geographic area, is genetically variable, and offers good opportunities for genetic gain through selection and breeding. Genetic gain will be realized through increased growth and survival in new plantations established with seedlings from improved seed. Growth of improved stock will depend upon good culture--a prerequisite for plantation establishment. Large, healthy nursery stock, good site preparation, and careful handling and planting will be necessary. Superior genetic material cannot overcome poor culture, nor can good culture overcome poor genetics.

Gains through geographic selection

Research studies have shown that, although no single area can be recommended for all of the South, trees from the Central Gulf Coast (southern Mississippi, southern Alabama, and western Florida) generally grow faster than more local trees in areas up to 150 miles north and 250 to 300 miles east and west of the point of origin (Wells and Wakeley 1970, Bey and Snyder 1978). At age 10, the southern Alabama seed source in the Southwide Pine Seed Source Study ranked first or second for percentage of trees in height growth at 10 of 12 plantations across the South. At the other locations, northern Alabama and eastern Texas, the Gulf Coast source ranked fourth and last for height growth initiation.

Height growth of the southern Alabama trees was also outstanding in most plantings mentioned above. In the longitude series of tests, the south Alabama source was tallest at age 10 at all locations but northern Alabama, west central Louisiana, and Texas. In these areas, trees from seed collected north or west of southern Alabama grew taller. The Southwide Pine Seed Source Study indicates that moving southern Alabama seed northward about 3° F of average annual temperature or 150 miles is both safe and advantageous.

For height growth and early height growth initiation, trees from southeastern and central Louisiana generally ranked low. In the Southwide Pine Seed Source Study, trees from central Florida, wherever tested, had poorer survival than those from other seed sources. Other tests show that western and northern Florida sources are acceptable for inclusion in breeding programs (Rockwood and Kok 1977, Bey and Snyder 1978).

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Longleaf trees from sandhills were once thought to produce progeny more resistant to drought than did Coastal Plain sources. A series of tests in 1951 and 1955, however, showed no differences in 1st- and 2d-year survivals or 10th-year heights between seedlings from sandhills and Coastal Plain soils (Wells and Wakeley 1970). But for 10th-year height growth initiation percentage, the sandhill sources had 11 percent greater initiation in North and South Carolina. On the Gulf Coast the Coastal Plain sources had 9 percent greater initiation. Because there are no survival and growth differences, the initiation differences are probably not of practical importance.

Brown-spot needle blight, caused by *Scirrhia acicola* (Dearn.) Siggers, defoliates longleaf seedlings and delays initiation of height growth. The disease occurs throughout the species range but is reported to be a chronic problem only on the Coastal Plain west of Panama City, Florida (Wakeley 1954). Development of resistant strains appears a promising solution to the problem. In general, research studies have demonstrated that seedlings from North Carolina and the western part of the longleaf range were more susceptible than those from the central part of the range, particularly the Central Gulf Coast (Henry and Wells 1967, Bey and Snyder 1978). Because the brown spot holds the seedling in the grass stage, trees from resistant sources are also the tallest. But inherent fast height growth is not the major mechanism of resistance. In a study with common families on two plots, the height growth of trees in families in a sprayed plot was poorly correlated ($r = -0.22$) with percent infection for the same half-sib families in an adjacent unsprayed plot (Snyder and Derr 1972). So selection for both resistance and growth will be needed in an improvement program, and separate progeny tests will be needed in each of the major areas where improved seed is to be used.

Gains through progeny testing

After the correct geographic area for seed collection is determined, the next step is to select individual parent trees. For longleaf, phenotypic selection in wild populations is not the most effective system of improvement. The variable effects of brown-spot infection, length of time in grass stage, competition, and fire mask the inherent growth potential of parents.

The short-term progeny test selection system is more efficient than phenotypic selection for longleaf (Snyder 1969). In one experiment, gains in plot volume at age 15 were 43 percent from progeny testing but only 15 percent from phenotypic selection alone (Snyder 1973). Although some moderate selection standards will need to be used, the emphasis should be on progeny testing many trees.

The progeny testing system involves collecting open-pollinated seed from many trees, using only moderate selection standards, and on the basis of the progeny test results selecting only about the best 20 percent of the parents. Valuable parent trees can now be identified within 5 years of progeny test establishment. Also, screening longleaf progeny for brown-spot resistance may be possible with artificial inoculation in the greenhouse (Kais 1975), a procedure that could significantly reduce the cost of progeny testing since the most susceptible families are eliminated before expensive field tests. Greenhouse and short-term progeny tests could save considerable time and money in making improvements in longleaf.

Besides identifying the best parents for grafting into clonal orchards, the progeny tests themselves can be rogued for conversion to low-cost seedling seed orchards (Snyder et al. 1977). Seedling orchards have particular merit for longleaf, especially where brown spot is a serious problem. Seedlings can be planted at close spacing in heavily infected brown-spot areas. Then as trees grow, brown spot eliminates the weak trees, and the resulting stand is naturally improved. Further periodic roguing to save the best individuals in the best families can give additional gain.

Gains from intercrossing the elite

Elite parents, identified through progeny testing, can be intercrossed to yield still greater gains. Two tests at Alexandria, Louisiana, show that at ages 12 and 13 the progeny of elite x elite parent crosses had greater survival and growth than progeny of random material. The general superiority at ages 12 and 13 can be attributed in part to their brown-spot resistance and early emergence from the grass stage (Bey and Snyder 1978). Elite trees in natural stands can be crossed, as can elite trees in grafted seed orchards or the best trees in the best families in seedling seed orchards. Plantations from crosses among these elite trees would also provide excellent opportunities for second generation selection.

Gains through interspecific hybridization

Difficulties with seed production limit use of hybrids. In general, crossing longleaf with other southern pines has been easy with slash pine (*P. elliottii* var. *elliottii* Engelm.), difficult with loblolly (*P. taeda* L.), very difficult with shortleaf (*P. echinata* Mill.), and impossible with pond pine (*P. serotina* Michx.). Seed yields for inter-species crosses vary widely depending on the individual parents.

Sonderegger pine (*P. sondereggeri* H. H. Chapm.), a hybrid between longleaf and loblolly pines, is the only formally named southern pine hybrid. It occurs naturally, especially along fringes of the longleaf pine range. In most years, among the four principal species of southern pine, only loblolly and longleaf and, in certain areas, slash and longleaf have overlapping flowering periods. The hybrid is easily distinguished in longleaf nursery beds and young plantations because of its early height growth and poor form.

Natural longleaf x slash hybrids occur infrequently, except in southern Georgia and northern Florida where flowering commonly coincides. The hybrid is easily made artificially and shows promise on dry, sandy sites. Height growth begins earlier than that of longleaf and the effects of brown spot are generally minimized. Unfortunately, the hybrid is not as resistant as longleaf to fusiform rust, but it is more resistant than slash pine.

Gains through direct seeding and natural regeneration

When available for direct seeding of longleaf pine, improved seed[2] offers potential gains comparable to using improved seedlings. Small gains beyond those from improved seedlings might also accrue from natural selection for brown-spot resistance, early height growth initiation, and rapid growth among the trees in the stand. Where improved seed is scarce, mixing improved seed with woods-run bulk seed should be effective. Improved seed would be included on each acre sown and presumably some crop trees in the resultant stand would be the improved types. Then if a shelterwood regeneration system were used, the new stand resulting at the end of the rotation should be as good as or probably better genetically than the original plantation.

The shelterwood system of natural regeneration in wild stands probably does little more than maintain the genetic status quo. Although mature trees that are phenotypically good-looking are selected as seed trees, from a genetic standpoint the selection differential is low (15 to 25 of the 200 to 400 trees per acre). Progeny testing has shown that judging genetic worth from phenotypic selection in wild stands is difficult. Where areas are heavily infected with brown spot during the establishment years, however, early selection may help improve the stand. If the disease holds back susceptible seedlings, more of the resultant stand would be resistant.

Just how fire interferes with natural selection is unclear. Where fire is common in early years, brown spot may be greatly reduced and any natural selection for brown-spot resistance is nullified. The timing of burns may also determine the effectiveness of natural selection. If a fire occurs just as the first trees of the stand are coming out of the grass stage, it may kill the very ones that could be the best genetic stock for the stand and future breeding.

So the future for improvement of longleaf pine looks bright. Over a wide geographic area, trees from the Central Gulf Coast area are generally faster growing than local sources. Short-term progeny tests and early roguing, coupled with good cultural techniques have also revealed that genetic gains can be made. As these procedures are put into practice, longleaf should regain its formerly prominent place among the southern pines.

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[2] Improved seed might consist of geographic source identified, individual tree identified, or seed orchard seed.

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QUESTIONS AND ANSWERS

1. Are you saying that the Kisatchie National Forest should not be using local longleaf seed in their planting and seeding program?

   Yes, tests on the Kisatchie have shown that trees grown from seed collected in the Central Gulf Coast area are superior in growth and brown spot resistance to the local sources.

2. Are superior tree qualities in longleaf the same as other southern pines?

   Traits like growth potential, small branches and straightness are basically the same for all southern pines. Traits like early growth initiation, initial survival and brown-spot resistance are more unique to longleaf.

3. Why does North Carolina not have a problem with brown spot as elsewhere?

   North Carolina is not unique in this respect. The brown-spot problem is reported to be minor in the east and increase to the west.

4. North Carolina has been using a Mississippi source of seed until recent years. How will this source compare in growth with native seed? Provenance tests have shown that in North Carolina local sources grow about equally with Central Gulf Coast sources and slightly poorer than South Carolina sources. Trees from the South Carolina sources are generally less susceptible to brown spot than are North Carolina sources. This might account for the growth differences.

5. Is natural regeneration (assuming phenotypic selection of seed trees) a dysgenic practice?

   No, the shelterwood system would not degenerate the genetic pool of the present stand.

6. Are we limiting genetic diversity in longleaf tree improvement programs?

   No, these programs include hundreds of selected trees that are genetically variable. These are dynamic programs and new selections (new genotypes) are always being added. In addition, crossing of these selected trees is "creating" new selections that in nature were never possible.

MARKETING & UTILIZATION OF LONGLEAF PINE

W. R. HELM, JR. [1]

Driving over from Tallahassee, I must have passed through two million acres of longleaf land. There was not a representative stand the whole way. If longleaf was a bird, it would have been designated an endangered species ten years ago. People tried to tell us when they endangered the red cockaded woodpecker, but we were too busy cutting trees to pay attention.

Over most of its range, it has been cut over and replaced by a "faster" growing species.

This is the name of the game; however, in Florida, longleaf is as close to a super tree as we have with relatively few enemies. It is difficult to establish artificially and in the southern extreme of its range it is hard to establish by any method with a seed crop every 9-12 years, but on certain lands, I feel it is certainly worth the effort. On the state forests of Florida, we converted several hundreds of acres to slash in the early 1960's. We have since plowed up much of this and are reestablishing longleaf.

Longleaf pine once covered vast areas of the south. This area was primarily virgin forests with high value markets. Today, longleaf is largely found in scattered second-growth forests and its products are difficult to separate from the other major southern pine species.

The market value of longleaf depends on the end use of a product. Perhaps the best way to explain such values would be to carry a longleaf stand from seedling to harvest (final).

Longleaf is not a prolific breeder. Therefore, very few stands achieve overcrowded conditions during an early age. However, as the stand advances in age, site conditions dictate some trees have to be removed. If these trees are small, sapling sized, one market that is opening today is energy wood. Selection of undesirable saplings to be removed may constitute a major product in some cases. Based on information available from studies and data from U. S. Forest Service, chips or fuel wood could be worth as much as $20-$40/ton as compared to fossil fuel cost of $.40/gal. of #2 fuel oil. At 50 gallons of oil per ton of wood, this breaks down to $20 you could afford to pay for a ton of wood and still be competitive with oil.

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[1] Chief, Forest Management, Florida Division of Forestry

The second selection in utilizing longleaf would be in the form of fence posts, pulpwood, and rustic fence products. At this time, competitive markets are making selection of some of these items more lucrative than others. An example: currently in South Florida, there are few or no pulpwood markets -- yet there is a tremendous demand for posts and rustic fence products. In North Florida, South Georgia, and Alabama, the pulpwood market is tremendous while posts take the back seat. Longleaf makes excellent posts because of its relatively slow growth when in the sapling stage, giving a larger number of growth rings per inch, which is desirable because it makes for more durable posts. Longleaf is one of the two pines from which naval stores are obtained; however, I have serious doubts at this time if a naval stores operation is economical or practical. There is some controversy over whether slash or longleaf is the best gum producing tree, but if the price were right and if an adequate labor force could be found, longleaf is certainly a satisfactory producer of gum resins. Gum is currently selling for $65 a barrel, which is less than 10% over the price of the same barrel in 1960. Gum farming would preempt an early thinning and cause a slight reduction of growth but is certainly an alternative to use on a maturing stand of longleaf.

Lumber remains a major product of longleaf pine. With the conditions in today's market, trees from 6-10" diameter are suitable for Chip-N-Saws and above 10" are suited for circle saws and bandsaws. In today's market, longleaf pine is still an asked-for commodity. Of course, longleaf and slash are sold under the term "longleaf lumber." Recently, however, several restoration projects around the country have specified longleaf only for their use. One project is the restoration of ships where the decking and keels are made exclusively from longleaf. Another project in Florida is a fort in Tampa which is made from longleaf logs and lumber. These are specialty users who normally expect to pay more to get good grades of longleaf lumber.

The market defines longleaf pine, thus separating it from Southern Yellow Pine. Now get this, longleaf lumber shall be produced only from Southern Pine tree species Pinus palustris and Pinus elliotii and shall average on one end or the other of each piece not less than 6 annual rings per inch and 1/3 or more summerwood measured on a radial line. Lots of longleaf won't qualify as longleaf.

Competing for sawtimber are the pulpwood and veneer markets. We have already discussed pulpwood. Veneer markets usually pay more than sawtimber or pulpwood; however, circumstances dictate prices so that is not always the case. The size of the veneer logs are determined by the end products such as panels or crate veneer. Pine has the characteristic of staying white for a long period of time, making it a desirable species for veneer crates in the vegetable shipping market. The plywood veneer market is a high end use of longleaf pine in its range.

The pole market in South Georgia, North Florida, and Alabama is one of the greatest factors affecting prices of longleaf pine in that area. The quality of longleaf poles makes it a desirable tree for this purpose. It is not unusual for a timber sale to be greatly affected because the stand contains a large percentage of quality longleaf pole trees.

Maximum profits from a longleaf stand can be obtained if the owner is familiar with the prices paid for various products in his area. Removal of trees and merchandising them to their maximum value is the best way to get the most money. Last year we received $240/M for 664/M board feet (International 1/4" scale) of longleaf.

Longleaf pine has always been in demand because of the quality of the products produced from it. This applies not only for those mentioned, but also for items such as stumps, piles, cross-arms, stave bolts and blocks for special purposes. The diversification of the marketplace is a major factor influencing the marketing and utilization of the longleaf pine.

Longleaf pine is one of the finest timber trees the world has known and I feel that longleaf seems to be coming back. Our nursery sales have gone from 50 thousand three years ago to over 2 million this year and it was the first specie to be sold out. There is a lot of land that used to and should be growing longleaf and I think time will prove this out. At least I hope it will. I'd hate to know that the Sierra Club held up the construction of a power dam because it was the site of the last remaining stand of longleaf.

Marketing of longleaf timber:

The state manages approximately 350,000 acres of forestland in Florida. One hundred eighty-five thousand acres of this is encompassed in the Blackwater River State Forest in Northwest Florida in Santa Rosa and Okaloosa Counties. The land was taken over in the 1930's and there remained the remnants of a cut-over virgin stand. Old photographs of the area showed thousands of acres with barely an average of one tree per acre. The current inventory shows that we now have 760 million board feet of sawtimber and approximately 700,000 cords of pulpwood and we average approximately 8/10's of a cord per acre per year in growth. We cut approximately 16 million board feet of sawtimber and 20,000 cords per year. We are on a 60-year rotation and we thin at about 14-year intervals always from below.

We mark and tally sawtimber and pulpwood and send out prospectus to some thirty potential buyers. Our sales are conducted on a lump sum basis. By that, the purchaser always pays for the timber in advance of any cutting. On our final harvest cut, of which we have had very few, we remove the shelterwood of approximately 30 trees per acre, 75% of which will be pole material. The average size of a sale on Blackwater River State Forest is between 750,000 and 1 million board feet and each sale is broken down into units of approximately 300,000 board feet per unit. We average about $185 a thousand international quarter inch scale, but have received as high as $240 a thousand. We feel that we have a very successful program and our annual income is between three and four million dollars per year.

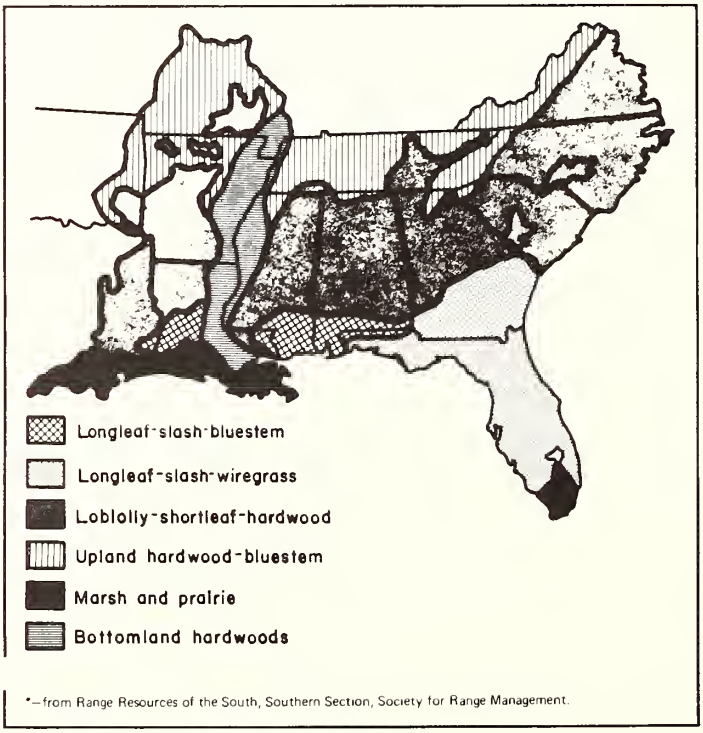
MULTIPLE USE ASPECTS OF LONGLEAF PINE

Nathan A. Byrd[1]

Abstract.--Longleaf pine types offer unique opportunities for multiple use management. The ease with which it can be safely prescribed burned at almost all ages, its attractive appearance, and associated plant and animal communities are some of the factors which make longleaf pine types desirable for wildlife habitat, range, and recreation management and use.

Additional keywords: Range management, recreation, wildlife habitat, *Pinus palustris*.

Longleaf pine (*Pinus palustris*) and the longleaf pine forest type are well suited for multiple uses (figure 1). High tolerance for, and actual dependence on, fire makes longleaf unique among Southern types. Because of a long history of fire in this type, associated flora and fauna have some degree of fire tolerance and/or dependence themselves. The beauty of park-like stands of sawtimber, broken by intermittent patches of dogwood (*Cornus florida*) and other fire resistant hardwoods, is admired by native and tourist alike. Writers and photographers have long used longleaf pine, spanish moss,(*Tillandsia ushedides*) and live oak (*Quercus virginiana*) as symbols of the rural South. Longleaf cones, often 25 centimeters or more in length, are favorite decoration items throughout the South. During the holiday season, these cones are shipped to other parts of the country for fabrication into wreaths, bells, and other items.



*—from Range Resources of the South, Southern Section, Society for Range Management.

Figure 1. Major range types of the South.

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[1] Multiple Use Specialist, Southeastern Area, USDA Forest Service, Atlanta, Ga.

"Heart" pine lumber, usually associated with remnant old-growth longleaf, is renowned for its strength and durability. Few have observed current management of longleaf stands, or realize the current economical and social importance of this forest type.

Although all of the non-timber uses of longleaf pine cannot be examined here, it is well to point out some of the most important. Hunting would certainly qualify under this heading. Hunters of bobwhite quail (Colinus virginianus) have historically preferred the "park-like" appearance of open sawtimber stands with patches of reproduction in small openings for escape cover. According to Halls and Stransky (1971), the heaviest concentrations of quail are found in the original longleaf type as described by Wahlenburg (1946). Bobwhite are primarily grass and weed seed eaters, and rather weak scratchers (Stoddard, 1932), so ground cover such as needles must be periodically removed through prescribed fire to allow grasses and legumes to grow and bear seed (Stoddard, 1932). Stransky (1971) recommended winter fires at 2-year intervals where possible. In seedling and young sapling stands the frequency can be lengthened, depending on the condition of grasses and herbaceous growth. Where escape cover such as drainages are more than 1/4 mile (400 meters) apart, unburned areas of low woody vegetation should be left for cover (USDA Forest Service, 1971). Although quail eat longleaf seeds when available, quail cannot depend on them for a steady fall diet because of sporadic production of cones and seeds.

Because quail need seeds from understory plants such as legumes, management strategies that hasten sapling and dense pole stands into more open sawtimber stands are desirable. If burned, stands with basal areas from 50 to 80 square feet (4.5-7.2 sq. meters) should provide quail habitat for moderate populations. Better populations are possible at lower basal area densities if timber management practices are coordinated for quail production. Where possible, harvesting and site preparation should not be done during the spring and early summer nesting seasons.

White-tailed deer (Odocoileus virginianus) are found throughout the longleaf area. The relatively open stands, particularly in the youngest and oldest stages, provide excellent shooting conditions. Prescribed fire also helps enrich and maintain the quantity and quality of deer foods within the feeding zone. Harlow and Jones (1965) and others found lower deer populations in the longleaf flatwoods than in the longleaf pine-oak uplands. Halls and Stransky's (1971) deer-kill map shows increased deer kills in areas containing a mixture of pine and hardwoods. Since white-tailed deer thrive on the succulent vegetation produced by silvicultural disturbances, frequent cuts will usually benefit deer. Care should be taken to protect key food areas such as mast producing oak stands, branch bottoms, and edges. Prescribed fire frequencies of about 3-4 year intervals provide ideal cover and food in most stands (Shrauder and Miller, 1969), (Harlow and Bielling, 1961). Early spring fires are usually best for deer habitat because vegetation responds quickly, permitting almost immediate use by deer. Winter burns improve food conditions almost as well and should be used where spring fires conflict with other uses.

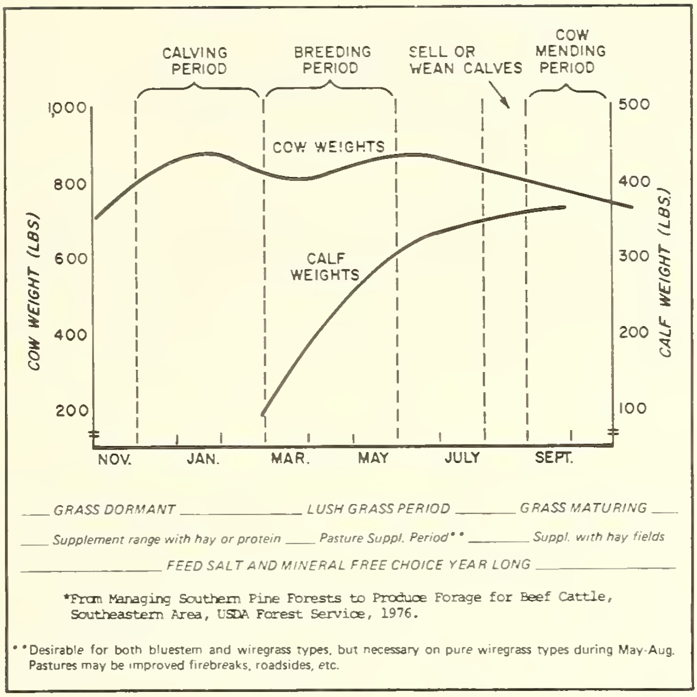
Fox squirrel (Sciurus niger) are fond of open longleaf woods and cover large areas, utilizing even isolated stands. Like the grey squirrel, (S. carolinensis) fox squirrels require hickory nuts, acorns and other foods supplied by hardwood stands. Management strategies designed to favor fox squirrels should, therefore, include retention of snags and patches of mast-bearing hardwoods.

The eastern wild turkey (Meleagris gallopavo) uses longleaf pine types for roosting and feeding, taking longleaf seed whenever available. Prescribed burning, except during the spring nesting season, helps to keep the woods open and provides better conditions for rearing their young.

Many other species of wildlife are affected directly and indirectly by longleaf management practices. The red-cockaded woodpecker (Picoides borealis) now on the Federal endangered species list, requires mature longleaf and loblolly (P. taeda) pine trees for nesting. Where federal funds are involved, the habitat of these birds may not be destroyed. The Forest Service's Southern Region protects red-cockaded woodpecker habitats by identifying cavity trees, managing buffer stands, and carrying existing and potential support stands to at least an 80-year rotation.

Wood and Niles (1978) report 68 species of birds that are year-round residents in the longleaf type. Many others use the type seasonally. Seedbed preparation burns expose seed for sparrows (Cerigillidae), robins (Turdidae), dark-eyed Juncos (Junco phaeonotus) and other species foraging in the area. On the other hand, burning eliminates the nesting habitat of several species for at least 1 year. But it is clearcutting, followed by intensive site preparation that has the most drastic effect on birds. For a time, the habitat structure contains very low niche diversity. Windrows add some cover for shelter and escape and eventually provide productive foraging areas. Longleaf seedling and sapling stands provide for large populations of non-game birds. As stands reach pole and sawtimber size and increase in basal area and crown closure, they become less productive in bird diversity.

Cattle have grazed in the longleaf-slash pine type even before there was management of timber resources for perpetual crops. Unfortunately, very little sound management has been applied to the forage resource in past years, resulting in mismanaged forest grazing operations. However, through research studies done by range scientists Cliff Lewis, John Cassidy, Ralph Hughes, Vinson Duvall, Henry Pearson and others, sound management programs have been developed. Because of its fire tolerance, particularly in the seedling stage, longleaf offers a better opportunity for coordinated timber-forage management than other Southern pines. Principal forage species are wiregrass (Aristida stricta Michx.), bluestem grasses (Andropogon spp.), panicum grasses (Panicum spp.), and paspalums (Paspalum spp.). Native grasses are not sufficient in crude protein, phosphorous and calcium (Lewis and McCormick, 1971). Wiregrass commonly associated with Southeastern longleaf types, must be burned for proper use by cattle and remains nutritious for only 3 months in the spring. Following a burn, bluestems and some other grasses remain more nutritious throughout the summer. However, all native range grazing should be supplemented by pasture and/or concentrated feed (figure 2). Sound management of forest forage calls for utilization of no more than 40 to 50 percent of annual growth. Any heavier utilization results in the replacement of the better grasses by less desirable species (Lewis and McCormick, 1971).

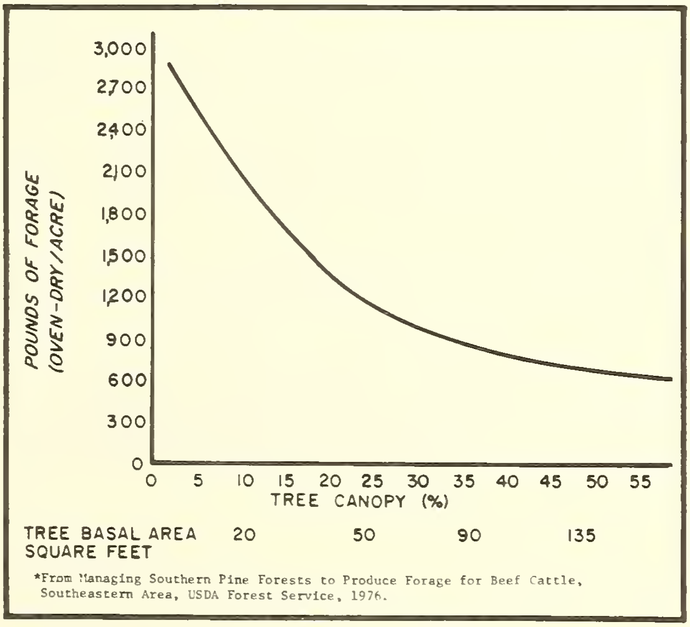


*From Managing Southern Pine Forests to Produce Forage for Beef Cattle, Southeastern Area, USDA Forest Service, 1976.

**Desirable for both bluestem and wiregrass types, but necessary on pure wiregrass types during May-Aug. Pastures may be improved firebreaks, roadsides, etc.

Figure 2. Expected weight gains for a cow-calf operation on managed southern forest lands with supplemental feeding.

Basal area increases result in forage production decreases (figure 3), making adjustments in livestock numbers necessary as the stand gets older (if stocked to full capacity initially). Care must be taken to modify animal stocking to protect livestock and young seedlings. However, if livestock are removed during the winter and stocking is moderate, this is usually not a problem.



*From Managing Southern Pine Forests to Produce Forage for Beef Cattle, Southeastern Area, USDA Forest Service, 1976.

Figure 3. Influence of trees on forage yields.

Natural regeneration techniques such as a combination of shelterwood and prescribed burning are compatible with forage production. Intensive site preparation often results in the replacement of grass by forbs. In such cases, single chopping and burning are good for forage production, while bulldozing and disking tend to retard it (Byrd and Lewis, 1976).

Natural longleaf sawtimber stands, with their graceful limbs, straight stems, and attractive bark, offer the ideal environment for picnics, hiking and horseback riding. Such stands are not as desirable for high use, developed recreation areas that require dense shade and diverse vegetation. Majestic roadside stands of longleaf, with fire resistant clumps of dogwood in the understory surrounded by a carpet of bluestem grass, have inspired many a photographer and painter.

Soils over the longleaf region vary greatly. Many areas have almost no water erosion problems because longleaf needle accumulations provide a complete soil cover for pole and sawtimber stands. Even after prescribed burns, most areas retain a thin organic layer which protects the soil from raindrop impact. Dissmeyer and Stump (1978) predicted erosion rates for disking to be four times higher than other site preparation practices in areas suited to longleaf pines. However, stream channel patterns, gentle slopes, and deep sandy soils, keep stream sedimentation low in those areas when compared with most areas where loblolly-shortleaf pine types are found in the Upper Coastal Plain and Piedmont.

In summary, longleaf pine management offers unique opportunities for wildlife habitat, recreation, and forest range development. Fire tolerance, stand development characteristics, and the inherent beauty of bark, needles and cones make longleaf particularly valuable for non-timber purposes and multiple use management. Also, since longleaf is highly desirable for structural timber, poles, pilings, and other products requiring long rotations, multiple use management opportunities are often greater than in loblolly-shortleaf pine types.

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OUTLOOK FOR LONGLEAF PINE - NATIONAL FORESTS

WALTER FOX[1]

ABSTRACT - Longleaf pine management presents more problems particularly with regeneration, than any other southern pine. These problems are identified and are being solved on the National Forests where large high quality longleaf pine trees will be grown in perpetuity.

Longleaf pine is the tree of the South, i.e., it is the pine of pines. Many of us have spent years working with longleaf, appreciating the tree and recognizing the problems of regeneration.

Four years ago, we in National Forest System management began to recognize that the problems of longleaf regeneration were not being solved by our Forest or District people, by and large. Regeneration efforts were failing, often more than once. More and more, longleaf cut-over areas were being put into slash or loblolly simply because it was easier to establish these species. Yet, research efforts over the years had substantially solved the regeneration problems of longleaf. So, what were we to do? The answer was really quite obvious - get help from Mr. Longleaf himself, i.e., Tom Croker at Brewton, Alabama. With the help and inputs of Tom, Bill Boyer, Bob Farrar, Bill Maple and others, we developed an intensive three day workshop on the silviclture of longleaf pine and it was intensive. We discussed the regeneration and management of longleaf pine from the womb to the log truck. We visited years of research work by Croker and staff.

During the planning period for the workshop we realized that three days could not possibly make experts out of us - we needed more than that. After Tom Croker retired, we were able to contract with him to visit all of our Districts managing longleaf to review problems and to provide on-the-ground training in regeneration and stand management. This turned out to be more than a one shot proposition. Some of our Forests continue to contract with Tom from year to year to use his expertise.

At our Longleaf Workshop, Tom discussed the original range of longleaf pine of 60 million acres and the shrinkage of this area to about 20 million acres. His concern was and is that the movement toward short rotation fiber production would mean the demise of the beautiful open stands of longleaf we've all known for so many years. So, where do we in the National Forest System, go from here?

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[1] Forester, Silviculture Group, Southern Region, USDA Forest Service, Atlanta, Georgia

There are presently 704,800 acres in longleaf pine management on the southern National Forests. These acres are and will continue to be managed to grow high quality longleaf trees on an 80 year rotation unless the Congress dictates otherwise. We estimate that the original area covered by longleaf on the southern National Forests was 1,250,000 acres. Thus, we're retaining 56% and we believe this to be the area best suited for the growing of longleaf. Much of the original acreage in longleaf was due to fire - natural and man caused while site suitability played a very minor role.

Many of our critics will claim that a program such as this is monoculture and in one respect this is true - the overstory is longleaf pine but the understory is composed of various species of shrubs, forbs, and grasses if the stand is properly managed, i.e. prescribed burned regularly and thinned when needed. In reality, this type of stand is quite natural in nature. Another answer to any monoculture charge can be found in the National Forest Management Act of 1976 (PL94-588) which states in part, "---where appropriate, to the degree practicable, for steps to be taken to preserve the diversity of tree species similar to that existing in the Region controlled by the plan." The plan referred to here is a land management plan. Longleaf management as practiced on National Forest land also provides many multiple benefits--

--habitat for many creatures large and small - deer, turkey, snakes, quail, the endangered Red Cockaded Woodpecker and many others.

--recreation enjoyment for people hiking, hunting, riding or just looking.

--watershed protection and enhancement for on and off site uses.

--tree harvesting to help supply wood products for the nation.

--grazing for cattle to help sustain the nation's food needs.

Longleaf can't provide everything for everybody but managed on sites to which it's suited, it serves many of our nation's needs.

As mentioned earlier, there are many problems connected with growing longleaf pine - probably more problems than with any other southern pine. While Tom Croker helped us make a substantial start to solving these problems there is still a ways to go. What are some of these problems?

1. Site selection. It is often difficult to differeniate between slash and longleaf pine sites. Many original longleaf sites are not in slash-some should be, some shouldn't. The same holds true for loblolly on much of the original longleaf range. And much of the original area of longleaf (i.e., 60 million acres) was probably off site as we think of site today.

2. Natural regeneration. There are many parts to this but without doubt, lack of consistant seed crops is the major problem. And yet a seed crop every few years would be considered a blessing in some parts of the country-last year when visiting Arizona, there was much talk about the last good seed crop - 1918! So, perhaps, 5-7 years isn't so bad. Except that

economic values suffer for wood products when a site does not maintain full productivity for 5-7 years. However, other values can compensate for this loss. Included in any natural regeneration scheme of course must be site preparation. Longleaf pine seed should germinate on mineral soil to insure seedling survival - other factors being equal. When too much soil is exposed, erosion takes place which can result in site deterioration. Site deterioration can also be caused by raking top soil into windrows during site prep. So, determining the proper method of site prep and doing this when a seed crop is predicated is a real opportunity. Following a very good seed fall, germination and growth, precommercial thinning may be needed - and this is a cost often overlooked by economic advocates of natural regeneration. Earlier, I mentioned the need for a regular burning program as part of longleaf pine management. A regular burning program controls understory vegetation and thus, usually negates the need for any site preparation other than another burn. But - environmental problems, not yet fully evaluated, may cause the loss of burning as a tool. What are we to do?

3. Lets look briefly at some problems of artificial regeneration. Site preparation here is much more apt to cause erosion and site deterioration because the sites must be completely prepared for planting or seeding. Longleaf pine seedlings are very sensitive and must be handled carefully. In addition, the seedlings have a limited tolerance to root planting depth changes from nursery beds. And, of course many longleaf sites are droughty sands and in some of these areas pocket gophers eat the plant roots even after the trees are 4-5 feet tall. Along with the seedlings we plant, we often get seed blowing in from trees around the edge of a regeneration area and of course, this completely ruins our attempts to control stocking. Direct seeding is getting more risky, We only use Endrin as a seed coat on one National Forest any more because of outside environmental pressures. We may be losing Arasan due to lack of sufficient markets to support production. What are we to do?

Enough of doomsday. We've made substantial progress solving the old problems and we'll certainly solve the new ones. Why, my friend Bill Mann is already working with the Kisatchie folks on solving the problem of seeding from the side by spraying the adjacent strip of trees with diesel oil to kill the cones.

These problems will only be solved through the cooperation of all of us who are interested in longleaf pine.

Ladies and Gentlemen - the outlook for longleaf pine on the National Forests is excellent, and there is little doubt that it will be grown in perpetuity.

OUTLOOK FOR LONGLEAF PINE FROM STATE'S VIEWPOINT

John M. McCullough [1]

Abstract.--The steady increase in recent years in demand for longleaf pine seedlings indicates a solid revived interest in establishing longleaf pine on proper sites in the Southeast. Improved nursery techniques, as well as better knowledge concerning field plantings of the species combined with a revival of old appreciations and the development of new ones form some of the factors in a predicted comeback of longleaf pine.

It is a privilege for me to discuss longleaf pine with you today. The traditional value, as well as romance of the longleaf pine, needs no further documentation. The role longleaf has played in the South for hundreds of years justifies workshops like this, as well as other professional attention it receives.

I like to compare longleaf pine to a good beautiful lady. Its attributes are without question. Its value is immeasurable. At times it is a blessing, as well as a source of frustration. At no time, however, does it lose its attraction. There has possibly been more written about longleaf pine than our other Southern species. This seems somewhat inconsistent inasmuch as it is presently considered a minor species in the trade. It is my strong feeling that it is no longer on the back shelf. I believe it is truly an established star performer which is making a genuine comeback.

It was momentarily overshadowed by the allure of slash pine. Much of the longleaf site has been occupied by slash, as well as loblolly. I feel, however, this trend has peaked and longleaf will once again regain its legitimate position.

In such a workshop as this, where I have the privilege of sharing the speakers platform with other much more learned scientists than I, there is always repetition regarding the subject. The very worthy subject we have today, however, I believe justifies some repetition. I am to present to you at this time my interpretation of the outlook for the longleaf pine from the State Forestry Agency's viewpoint. To do so I think it would be helpful if we made casual review of the species we are concerned with at this time. In doing so I will refer first briefly to the range of the longleaf pine.

Generally the natural range of the species is indicated by most authorities as ranging approximately 150 miles inland from our Southern coastline. This is true in Alabama. Furthermore, several counties in North Alabama are identified as containing longleaf sites. Over thirty-four counties out of the sixty-seven in Alabama contain stands of longleaf pine. This comprises some 1½ million acres in this type. I will venture a personal guess that longleaf sites cover more than this, probably as much as 15 percent of the State's total forest land or some 3.2 million acres. This is not a documented figure; it is a personal estimate and subject to review. When we consider, however, the drastic conversion of longleaf stands to slash pine, as well as loblolly, during the past twenty years and assume that most of the longleaf stands which were natural were located on longleaf sites, it is easy to expand our concept regarding the total longleaf site acreage in the State. I feel fairly confident that these estimates would likely apply in the same proportions in the other states with longleaf stands.

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[1] Director, Forest Resources Development Division, Alabama Forestry Commission, Montgomery, Alabama

One of the best indicators we have within the Alabama Forestry Commission concerning the interest in various species of forest trees is the demand for seedlings from our state nurseries.

A scanning of these records indicates that in the early fifties we were shipping between three and four million longleaf seedlings per year. This was out of a production of approximately 50 million trees. Longleaf demand peaked around 1960 at 5 million trees. This was during the growing days of the soil bank program at which time we shipped an average of approximately 130 million trees or so per year.

The soil bank era naturally created a peak which dropped drastically following the close of the program. Nevertheless, while other species recovered from this drop and gradually increased in demand, longleaf seedlings bottomed out around 1970 at ½ million trees per year.

Beginning about 1970 the longleaf demand began to increase and has done so steadily to the present, 1978, during which we expect to ship approximately 5 million longleaf seedlings.

Casual estimates indicate the following projections for longleaf demand. Five years from now, or 1983, we expect a demand of 7½ million seedlings. Three years later, or by 1986, we anticipate a demand of 10 million seedlings. Beyond that we are going to hazard a guess of an ultimate demand of 12 to 15 million seedlings for longleaf pine. This is expected to be approximately 10 percent of our total pine seedling production at that time.

I would like to qualify these figures in a modest way with the observation that public demand for forest tree seedlings is somewhat fickle. For example, over the years we have adjusted our production of various species in response to the demand of the previous seasons. Quite often, however, after having planned over a year in advance for a particular production of a species we discover that the seedlings ordered indicate a flip-flop on the attitude of the landowners. I am not sure whether this inconsistency is an accordion action precipitated by the landowners trying to anticipate state supply or whether it is a genuine conviction on their part concerning species preference. I rather think it is the latter. Here I refer to the demand for slash pine. Even though there has been some annual fluctuation back and forth compared to loblolly, the long range trend has definitely been toward a drastic reduction in slash pine demand. For example, at the present our loblolly-slash production ratio is approximately 80-20 in favor of loblolly. Around 15 to 20 years ago it was the reverse.

I am convinced that long range trends in seedling demand do indicate a solid attitude on the part of landowners concerning a particular species.

While there are general, as well as local factors, which influence a particular landowner in his choice of species, I do not feel this invalidates the significance of the long range trend. Therefore, we come back to the conviction that longleaf pine is on the way up.

It might be of interest to review some of the reasoning behind this increased interest in longleaf pine. I feel there are three principal reasons. There are others I am sure. Also I might have overlooked a very important reason, and will welcome any contribution in this direction that is offered.

One of the most important reasons I think for the recovery of the longleaf pine is the improvement in nurseries techniques. These include lower seed bed density, larger more uniform seedlings, better root system development and better soil management in general. New importance has been given the mulching process with the use of sawdust and other mulches, fertilizing techniques to offset the effects of sawdust decomposition, such as nitrogen loss, as well as the lime content of the soil.

Better grading procedures have also been recognized by the nurseries. The critical importance of the root collar diameter has been reemphasized. Further emphasis has been given to the development of a good lateral root system with plenty of mycorrhiza. Also there is a valid importance to longleaf pine of the root-crown ratio.

The second major factor affecting longleaf demand has been improved planting techniques. We have given attention traditionally to the depth of seedlings in the ground by probably over emphasizing the damage from soil in the bud. It seems to have been established in some circles that far more damage can result from exposing the root stem to the air than allowing some sand in the bud. Furthermore, the technique of root pruning has been improved and increased the survival of the species in plantations. More also is known today about the importance of site preparation for longleaf planting. The degree of preparation as usual would depend on local conditions. Nevertheless, proper site has been recognized as a critical factor. Many experienced planters testify, for example, to the effectiveness of bedding the site for longleaf pine.

A third major factor in the increased popularity of longleaf is just a plain new appreciation for the species. This appreciation recognizes again some of the traditional pluses. The very strong resistence to fire once it obtains three feet or more in height is still a very important item. The disease resistence of the species is of new significance as we are faced more and more with the preponderance of diseases and insects that persist in decimating valuable plantations. Probably the most serious enemy of longleaf pine, brownspot disease, has always been controlled with prescribed fire. Some of the diseases of the older trees, such as red heart, are not expected to be a serious factor in view of increased knowledge regarding stand management. Furthermore, natural reseeding using prescribed fire is repeatedly successful in many instances throughout the longleaf belt.

Another traditional value has been the general good quality, lumber wise of the species. The clear bole, the straight trunk, the lack of twist and the even growth has been recognized in favor of the species, and I believe these qualities will become even more important as highgrade lumber becomes less plentiful. The traditional favorable market of the species will probably be enhanced in the future.

Even the rotation age for longleaf is becoming more acceptable in view of new environmental concerns and a new look at the species itself. Peter Koch in "Utilization of Southern Pines" (1972) says eighty years under management will produce what 200 years did in unmanaged stands.

Some of the more recently recognized values of longleaf pine include its adaptability to artificial regeneration. More and more experienced planters are having less and less criticism of the species as far as its plantability is concerned. Furthermore, it is very acceptable aesthetically as it produces less clutter in harvesting operations. Also, as stated previously, it fits into present day concerns with somewhat longer rotations. The disillusionment with slash pine is probably a factor also in the recovery of longleaf. Apparently we are discovering that slash pine is more site specific than we had thought. Added to this is the favorable comparison in volume production that longleaf shows on longer rotations.

Longleaf is especially useful on public lands. The longer rotation, as well as the aesthetic value of the species, are points in its favor on public ownerships. At Geneva State Forest, for example, in Geneva County, Alabama, 92 percent of the area is longleaf site. The management plan for Geneva State Forest includes a seventy-year rotation. Improvement cuts and thinnings, as well as isolated regenerated areas, are carried out with no criticism from the public so far.

I have offered above some of my viewpoints, good or bad, concerning the increased popularity of longleaf pine. Some of these observations might be erroneous. Some of them might be too liberal or even too conservative. I still feel, though, that in general they are in the right direction and I have confidence that their indication of a 12 to 15 million seedlings demand by 1990 is a good possibility. It is encouraging to me to think that we will once again restore and respect an old friend in the South--the Longleaf Pine.

Thank you.

OUTLOOK FOR LONGLEAF PINE PANEL--INDUSTRY

W. H. Parker, Jr.[1]

Abstract.--Currently the south produces 75% of the poles harvested in the United States. The acreage of longleaf pine, the preferred species for poles, is on the decline. Other materials such as steel, concrete, laminated wood, and fiberglass have made inroads into the pole industry. Since 1975, the demand for poles has gradually increased and should continue this trend into the 80's.

First, let me say that any of the statements I make here today are the opinions of Koppers Company and not necessarily those of the treating and/or pole and piling industry as a whole.

Utility companies and construction firms have always looked to the South for supplies of poles and piling and will continue to do so. Most recent figures show that the south produces 7 of every 10 poles or about 75% of the poles harvested in the United States annually. The remaining 25% is produced mostly from the western species. This 75% figure includes most of the southern pines--longleaf, slash, loblolly, and shortleaf. I do not know what percentage of the southern pine poles are longleaf pine, however; we can be assured that the most preferred species of the southern pines is longleaf. The reason being that the longleaf has some very desirable characteristics. A few of them are as follows:

1. It has a good wide sap ring which permits deep penetration of preservatives.

2. This species is consistently one of the straightest. Usually the knots are small. A stand of longleaf will produce up to 75% poles, a percentage higher than that realized from most of the other southern pines. This fact makes a stand of longleaf more economical and easier to harvest.

3. The form is exceptional with good average taper.

4. The strength/weight ratio is very good as it is one of the strongest conifers.

5. It is economical to manage and can be easily reproduced naturally.

6. This species grows in a fairly wide geographic range which makes it more accessible to transportation.

As you can see, the longleaf pine has many characteristics in its favor when it comes to the pole and piling industry. Currently, the supply is adequate, but we don't know about the future. The longleaf pine region once supported approximately 60 million acres of this desirable species. Today the amount has dwindled to about 5 million acres. This decline is due to many factors; one of which is the converting of natural longleaf stands to other species of southern pine. This practice continues in some areas, however; we are seeing evidence that more people are now continuing to grow longleaf, especially on certain sites. We certainly hope this idea continues and our company is going to try to help maintain this trend. I will go into more detail on this in a few minutes.

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[1] Procurement Manager, Forest Products Division, Koppers Company, Inc., Salisbury, Maryland.

Utility poles are the most important quality product and comprised three/fourths of the mid-south's pole production in recent years. The popular sizes are in the 30 to 40 foot range, which are readily found in stands of longleaf. R.E.A. uses 35% of the pole supply and is the biggest user. Utility companies follow with 32% of the consumption. The telephone companies use about 25%.

Moves to higher voltages and more stringent clearance requirements for conductors have increased the average pole length by five (5) feet in recent years. There has also been a decline in the availability of southern pine transmission poles (those over 50' in length) in recent years. The industry has had to go to the western species to fill the need.

The demand for poles has steadily increased in recent years, with the years 1973-74 being the peak period. During this peak time about 2.6 million southern pine poles were produced. In this period of high demand the poles and piling harvested amounted to 1/4 of 1% of the total pine harvested in the southeast. The pole market bottomed out in 1975 when the production went to a low of 1.5 million. The reason for this low production was that everyone was living off of their large inventories. These inventories were built up in 1974 in anticipation of the future market being like the 1973-74 market. We expect the 1979 market to go to 2.0 million with a gradual increase in demand in the 1980's. During the booming years of '73-'74, the treating industry could not meet the demand. It was during this time that most of the utility companies were using the philosophy of: "If I order twice as many as I need, I am sure to get what I can actually use." This is the period when laminated wood, concrete, steel and fiberglass made inroads into the industry.

There are many disadvantages to using unnatural poles. For example, laminated wood poles, which are the first alternative, cost 2 1/2 times more than a regular pole. The laminated pole came into use in 1974. It has several obvious advantages, but not enough to offset the high price.

Concrete poles have a weight problem which necessitates local manufacture most of the time. This weight factor makes freight very costly. These poles cost 2 times more than regular poles. Some utility companies have used concrete poles as a substitute, but most of these companies depend on wooden poles for their main supply of poles. Concrete poles are also very costly to install. Because of the weight factor, it is necessary, in many instances, to install a concrete foundation for anchorage.

Steel poles also have a weight disadvantage. In addition to this, there are many problems in the fabrication of steel poles at the field level. However, steel poles are competitive when rated by cost per mile; the reason being that steel has a longer structure span.

Fiberglass poles are used mostly for decorative lighting. These poles are slightly more expensive and they do not weather well.

The telephone companies are going more to the 'plow and bury' technique. This has caused a significant decline in their consumption of poles. Some home buyers, when they have the option, are still going with the pole rather than with the $800.00 average cost for going underground.

Utility poles are the most important product while the production of barn and/or building poles amount to about 6% of the total pole production. In addition to poles, about 25,000,000 linear feet of piling is produced annually. The average piling is about 45 feet long which is another size range that fits into the longleaf picture.

The piling market seems to be expanding. One reason for this is dual treatment of CCA and creosote--which increases the life expectancy of a piling up to 20 years. More house piling are being used along the entire coastal areas of the United States than there have been in the past.

Another important product in our business is dense structural lumber, and timbers which are produced mostly from longleaf pine. The demand for these products has been on the increase in recent years, especially for sawn timbers.

From all indications, it appears tht the demand for these quality products poles, piling, and dense structural lumber will gradually increase along with the overall increasing consumption of wood fiber in the United States.

In 1964, the aggregate value of poles and piling harvested in the mid-south and delivered to plants exceeded 21 million dollars. The demand for these quality products, poles and piling, has kept stumpage prices favorable and should continue to do so. For example, one study revealed that the returns from stands managed for pulpwood and sawtimber alone were only 62% of the returns for the same stands managed for pulpwood, sawtimber, and poles. This is just a small indication of the important role that longleaf pine takes in the mid-south's economy.

The increasing demand coupled with the decline in longleaf pine acreage has caused our company some concern about the future supply of poles and other quality products. As a result of this, Koppers Company is entering into a landowner assistance program, entitled 'K-PAL, Koppers' program for assisting landowners. Our program provides some of the same services that the other wood-using industries with assistance programs offer. However, K-PAL is different from most of the assistance programs in the following respects:

1. It uses the landowner's objectives as the basis for formulating the management plan.

2. It is designed to serve primarily those landowners in the longleaf pine belt.

3. It uses the shelterwood method of management and it considers various end markets for timber to provide maximum financial, recreational and wildlife benefits over a management period.

4. It uses the computer program 'WRAP" (Woodland Resource Analysis Program in identifying and evaluating strategies to accomplish the objectives of the landowner.

We believe that K-Pal, as well as other landowner assistance programs, can be extremely beneficial in increasing the productivity of our woodlands--to the advantage of the country as well as to the individual landowner's advantage.

SUMMARY

In summary there is a demand for quality products such as poles and piling and it appears that this demand will continue. Longleaf pine is the preferred species for poles even though other southern pines are used. There has been a drastic decline in longleaf pine acreage over the years and Koppers Company hopes to help reverse this trend with its assistance program. Koppers Company has an obligation to furnish our customers with the best products and we think that the longleaf pine is and will continue to aid us in fulfilling this obligation.

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QUESTIONS AND ANSWERS

Q. In what states and areas will you offer your K-PAL services?

A. In all the states in the longleaf pine range from North Carolina to Texas.

Q. On the assistance program with landowners, how many or what percentage of landowners have been sold with regenerating longleaf and use the seed tree/shelterwood method?

A. I can't answer this at this time as our program has not been started as of this date. We hope to start our K-Pal program in the near future.

OUTLOOK FOR LONGLEAF PINE ON PRIVATE NON-INDUSTRIAL LANDS

L. Keville Larson [1]

Abstract.--In the past most longleaf has been cut rather than grown on private lands. Because there were few efforts to replace it, the acreage of longleaf forest type had declined drastically, but the situation is improving.

Elimination of longleaf has been both unintentional and deliberate. In many cases landowners have cut and left property to regenerate completely by itself, with no effort at providing seed source, seed bed or other favorable conditions. State and other fire protection programs often kept these areas from burning which allowed invasion of the former longleaf sites by other pine species or hardwoods. Once other species were established and with fire excluded, longleaf could not regenerate or compete and was eliminated. It requires aggressive burning to prevent complete crowding out of the longleaf when other pine species invade a longleaf stand. In other instances, attempts to continue growing longleaf were unsuccessful because regeneration methods were not known or understood. Following the lead of pulp and paper companies in intensive site preparation and replanting since the late 1950's resulted in deliberate efforts by some private nonindustrial landowners to eradicate longleaf and convert to slash or loblolly pine. During this time the emphasis was on acheiving stocking rapidly and producing fiber. Other species were easier to handle and longleaf had unsolved problems. Difficulty of natural regeneration and planting and slowness of early growth, were the primary reasons for discriminating against it.

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[1] President, Larson & McGowin, Inc.-Forest Managers and Consultants

The outlook is improving. There have been several gradual changes over the past 10 to 15 years which contribute to a brighter future for longleaf on private non-industrial lands. The first and perhaps most important is more landowners are seeking professional forestry help. This is a result of more awareness and interest because of higher values and more sources of professional help. At the same time, attention is focusing on intensive forestry, such as matching the species to the site rather than simply putting trees in the ground. Two important changes during the past 10 to 15 years have been the development and refinement of techniques to regenerate longleaf pine naturally and the widespread acceptance of prescribed burning as a silvicultural tool. These may be the two most significant factors to the improved outlook for longleaf pine on private non-industrial lands. One other factor which may become increasingly important, as low quality plantation wood comes on stream, is the extra value which can be obtained from the higher quality of longleaf.

There are several reasons for recommending longleaf pine. First, there are certain sites best suited for its unique characteristics, sites where other species might not do as well. Similarly there are certain locations of high fire hazard, and in these areas there is less risk of loss with longleaf than with any other specie. Longleaf is also more resistant to some diseases and insect problems. With proper silvicultural practices, it can be regenerated naturally using a shelterwood method. This has important advantages for private owners. Using natural regeneration rather than planting avoids large capital outlays, and the shelterwood method allows more continuous production of merchantable volume, thus providing a longer time of income opportunity. These are desirable investment characteristics for many private non-industrial landowners.

Longleaf has a real advantage in producing a good diversity products, pulpwood, posts, poles, sawtimber, plywood and naval stores. When one market is down, it may be possible to sell another product. Compared with loblolly or slash, its quality is better suited to producing high value products, which is appealing to owners who concentrate on dollar return rather than rate of return.

There are also less significant reasons contributing to the appeal of growing longleaf. Prescribed burning, the primary tool, can be learned and carried out by some landowners. Longleaf forests can be used for grazing range, and are desirable for game and recreation uses. Not to be completely discounted as a motivating force is the emotional attachment, interest and dedication to perpetuating the species, frequently found in the owners of longleaf forests. They cite the unique characteristics, the aesthetic appeal, the strong history and the decline in acreage from 60 million to less than 10 million as reasons inspiring their special interest. Theirs is a pride unmatched by other forest owners.

Several years ago, the outlook for longleaf pine on private lands could not have been worse. Credit for the improved outlook can be given to certain inherent superiorities of the species, dedicated research by men like Thomas C. Croker, Jr. and the blind faith of some landowners and foresters who have preserved and managed longleaf areas. We now have good sound silviculture research, but need further work in genetics, nursery and planting, and need to put the results in the hands of foresters who will deal with and recommend practices for private landowners. With proper advice, many will continue to grow the longleaf they have, and others will see the merits of investing in conversion to longleaf.

THE OUTLOOK FOR LONGLEAF PINE FROM A RESEARCH STANDPOINT

W. F. Mann, Jr. [1]

Abstract.--Many factors caused a drastic decline of acreage in the longleaf pine type. Most objections to longleaf have been overcome, and it can be regenerated by natural or artificial means as reliably as the other southern pines. Moreover, early height growth can be accelerated by improved nursery techniques and use of genetically improved material. Longleaf will be regenerated more extensively in the future, especially on dry, adverse sites and where fusiform rust is a severe problem for loblolly and slash pines.

Additional keywords: *Pinus palustris*, regeneration, growth, disease resistance, geographic range, tree improvement, prescribed burning.

A brief look at the history of longleaf pine (*Pinus palustris* Mill.) and the factors that led to its steady decline will help in forecasting the future role of this species.

Longleaf was once the predominant pine species in the South, but the exact acreage was never determined. Wahlenberg (1946) estimated virgin stands originally extended over 30 to 60 million acres. Walker and Wiant (1966) placed the acreage at about 50 million acres. It is equally difficult to pinpoint the extent of the longleaf type today. Boyer, using Forest Survey data for individual states from 1966 to 1975 for the longleaf-slash pine (*P. elliottii* Engelm.) type, proportioned acreages by volumes of the two species to show about 5.5 million acres. [2]

Clearcutting second-growth longleaf stands to plant slash pine has continued since these Forest Surveys were made. Overall, liquidation probably exceeds replacement even today. For our purposes we can assume longleaf now extends over 5 million acres. As a result of the vast decrease in acreage over the last 100 years, the volume in this species has declined from 400 billion board feet (Mattoon 1922) to about 1 billion board feet.

The most important factors in the decline in interest and prestige of longleaf are annual wildfires; failure to leave seed trees when clearcutting virgin stands; domestic animal damage; brown-spot needle disease (*Scirrhia acicola* (Dearn.) Siggers); low planting survival; slow juvenile height growth; a shift towards shorter rotations and greater production of pulpwood; and the widespread misconception that longleaf grows more slowly than slash or loblolly (*P. taeda* L.) pines.

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[2] W. D. Boyer, South. For. Exp. Stn., Auburn, AL, personal communication.

Most of the objections to longleaf are no longer valid. Woods hogs and sheep, that uproot and debud young pines, no longer roam forest ranges in significant numbers. The numbers of annual wildfires, that often accompany cattle grazing prevalent on grassy longleaf sites, have declined greatly.

Techniques have been developed for growing high-quality nursery stock with a potential for survival equal to loblolly and slash pines (Mann 1969). Sowing longleaf nursery beds in fall, growing about 15 seedlings per square foot, root pruning stock to about 7 inches 6 to 12 weeks before lifting, and clipping needles back to 5 inches immediately before planting adverse sites, all increase survival and, with the exception of clipping, boost early growth as well. Even though longleaf requires more care in handling between the nursery and the field than other species, the procedures are not unreasonable. Longleaf is simply less tolerant of mishandling than other species.

Although longleaf is often classed as an intolerant species, Croker (1956) and Boyer (1976) demonstrated that the shelterwood system is a practical, effective method of regenerating longleaf naturally. Their system maintains volume production in the large trees retained for seed production during seedling establishment. Pilot tests in many parts of the South indicate this method is more reliable than regeneration by the seed-tree method.

Direct seeding, perfected in 1957, has been used effectively on a wide array of sites (Derr and Mann 1959). Longleaf is the easiest of the southern pines to direct seed because the seed germinates quickly and mechanical seedbed preparation is often unnecessary. It was once thought only fresh longleaf seed could be used. But as part of the direct-seeding research, means have been found to keep longleaf seed viable for 10 years or more, making it possible to plan orderly yearly sowing programs rather than gear operations to infrequent seed crops.

Other advances have been made in addition to those for regeneration. We now know more about prescribed burning, the only practical method of controlling brown-spot needle disease. For years, we estimated the amount of needle infection from all seedlings, and burned when 30 to 35 percent of the foliage was diseased. Consequently, burns were often ill-timed and survival and growth of dominant seedlings impaired. In the crop-tree method of estimating needle infection, only the best seedling on each milacre is appraised for disease (Croker 1967). Also, it was recently found that late spring burns were more effective in controlling brown spot and promoting growth than the late winter burns that had been recommended for decades (Grelen 1978).

Advances in tree improvement research (Derr and Melder 1970, Derr 1971, Snyder and Derr 1972) have identified about 60 trees whose progeny are highly resistant to brown-spot needle disease and initiate height growth 2 and 3 years after planting without the aid of prescribed burns. Scions from these trees and their superior progeny are available at no cost. But this is only the beginning of the solution to the problem of longleaf's slow juvenile height growth. The so-called grass stage can be further shortened by crossing two resistant parents (Derr 1970, Snyder *et al.* 1977). Unfortunately, there are indications that families found highly resistant in one area may be more susceptible in another (Snyder and Bey 1978).

Longleaf's reputation as a slow grower is largely a result of the time it takes seedlings to develop beyond the danger of serious brown-spot infection. With tree improvement research identifying strains that are disease resistant, growth losses attributed to a long grass stage will be minimized. Once longleaf attains a height of 5 or 6 feet it will grow as fast as loblolly and slash on comparable sites (Derr and Enghardt 1969; Farrar 1974, 1978; Lohrey and Bailey 1977).

Research on containerized seedling production and planting, underway for 5 years, shows that this new technique is well adapted to longleaf pine. Twelve-week-old seedlings have showed high survival and rapid growth when planted at most times of the year. Interim recommendations for growing seedlings are now available (Barnett in press).

Growth and yield data have been published for natural and planted longleaf stands (Farrar 1974, 1978; Lohrey and Bailey 1977). Ongoing studies in Louisiana and Alabama will refine these data regularly, permitting forest managers to better judge longleaf's growth capability.

These are only the highlights of significant progress in our knowledge of longleaf pine. It is, by no means, a complete account of all research and developments. One fact is clear--researchers have not written off longleaf as an obsolete species. On the contrary, the latest information and techniques should accelerate a comeback by this desirable species. Much remains to be done to make longleaf a more attractive alternative in southern forestry. Screening trials for brown-spot resistance and fast, early juvenile height growth are needed to identify superior families for broad geographic areas. Second generation breeding with superior, disease-resistant, fast-growing parents rates high priority in research. We must also define optimum seed sources for different areas more precisely. Additional information is needed about soil-site relationships throughout the species' range, and how well longleaf performance compares with that of loblolly and slash on a wide variety of soils. We must determine how longleaf responds to fertilizers, especially on adverse sites. We need to know how longleaf responds to site preparation and amelioration treatments, and how such treatments interact with brown spot when resistant trees are planted. And we must continue research on nursery culture in order to consistently produce seedlings of high physiological quality.

Longleaf pine has a major role in future southern forestry. How much of its former prestige longleaf will regain depends somewhat on future processing plants. The current trend toward diversification of utilization facilities and continuing high demand for solid wood products favor longleaf. We should avoid a tendency to relegate longleaf to the driest, sandy soils. The fact that virgin stands existed on a broad array of sites clearly suggests it can grow well under a variety of conditions. Where fusiform rust (*Cronartium fusiforme* Hedgc. & Hunt) is devastating to loblolly and slash pines, longleaf is currently the only logical alternative. It is time for forest managers to put aside old notions and take a new look at longleaf pine.

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LONGLEAF PINE WORKSHOP
FIELD TRIPS

Escambia Experimental Forest

STOP 1

LOXLEY THINNING PLOTS

Status - Thirty-two permanent 1/10 acre plots were established in 22-year-old natural longleaf stands on site index 70 in the winter of 1933-34 and have been re-measured at 5-year intervals. The range of residual densities created initially have been maintained and broadened by periodic low thinnings. This is one of the oldest, continuously monitored studies of southern pine growth and yield. Data spanning a 45 year period will soon be available.

Principal results - The major indications from this study are that nearly maximum merchantable cubic volume growth and yield up to about age 50 may be obtained by maintaining medium stand densities (about 60% of "normal" basal area as a guide) by frequent and moderate low thinning. Results further suggested that such practices would increase the yield of sawtimber-sized material by concentrating growth on fewer larger stems. Additional possible benefits from maintaining medium densities are increased forage and wildlife food plant production. Application of suggested thinning practices would increase intermediate management returns from thinnings, increase the yield in large stems, and should enhance grazing and wildlife production in natural longleaf forests. Experience with this study also contributed greatly to the design of subsequent and more comprehensive studies.

Plans - A summary publication covering the entire 45 year time span is in process.

STOP 2

WELCOME TO THE ESCAMBIA EXPERIMENTAL FOREST. This 3,000 acre field laboratory was established in 1947 by the Southern Forest Experiment Station, primarily to study problems associated with the management of longleaf pine forests. T. R. Miller Mill Company of Brewton, made the land available to the government without cost under a 99 year lease. Products derived from operations on the Escambia go to the Company.

Due to its central location in the longleaf pine belt that extends from the Carolinas to Texas it is well situated for the study of this species. In the heart of the Middle Coastal Plain Province where much of the second growth longleaf is growing, it is near three other provinces that contain longleaf; the Lower Coastal Plain, Piedmont, and Mountain Valley.

About 80 percent of the forest is in the longleaf type with the remainder in slash-hardwood bottoms. Research operations here have developed many age classes of longleaf from newly germinated seedlings to plots with trees 160 years old. Nearly 1000 acres have been naturally regenerated, and two-thirds of this is in stands ranging from 20 to 30 years of age. Many stand densities have been created in the longleaf stands, particularly in connection with the growth studies. Site quality is extremely varied, averaging about 70 feet for 50-year longleaf.

Escambia researchers have investigated many longleaf problems here. These have included regeneration, stand management and growth, site, fire ecology, woods grazing, and a few studies in the branch bottom type. Much of the basic research and development of the shelterwood system for longleaf regeneration was done on the Experimental Forest.

At this stop is an example of longleaf pine natural regeneration achieved by the shelterwood system. Pertinent data:

Size of unit:	43 acres
Year of seed cut:	1972
Age of stand:	3 years (from overstory removal)
Present stocking:	5,000 seedlings/acre 72% of sample milacres stocked
Recent cultural history:	Winter burns 1974, 1978 Hardwood control (injection) 1971, 1978
Present plans:	Spring burn 1979 for hardwood sprout control

STOP 3

Longleaf pine shelterwood stand

Size of unit:	42 acres
Year of seedcut:	1973; 1977 (rapid growth of residuals raised density from 30 to 45 sq.ft./acre)
Present stocking:	5,000 seedlings/acre (1975 seed crop) 87% of sample milacres stocked
Recent cultural history:	Fall seedbed burn 1975 Hardwood control (injection) 1972, 1978
Present plans:	Spring burn 1979 for hardwood brush control Clearcut any time after post-burn seedling check

STOP 4

HOLLY FORK PLANTATION, T. R. MILLER

Size of unit: 400± acres of longleaf.

Age of plantation: 5 years.

History: Essentially complete site preparation-cleared, debris piled & burned, disced, large hardwoods killed. Properly machine-planted with good 1-0 stock. Dominant seedling stand reached b.h. in 2 to 3 years.

STAND DATA PER ACRE[1]

Plot#	Age	Yrs. to b.h.	Avg. d.b.h.	Dom. Ht.	Trees/Acre		Basal Area	Cubic Vol., dbh ≥1"	
					All	dbh ≥1"		o.b.	i.b.
125	4	3	1.1	6.6	600	236	1.6	11	5
126	4	3	1.0	6.8	306	96	0.6	5	2
127	4	2	1.2	7.5	528	375	3.2	24	12
128	4	2	1.0	6.5	418	86	0.5	4	2
Avg.	4	2.5	1.1	6.9	463	198	1.5	11.0	5.3

OTHER T. R. MILLER PLANTATIONS, SHADY GROVE

STAND DATA PER ACRE

Treatment[2]	Age	Age to b.h.	Avg. dbh	Dom. Ht.	Trees/Acre		Basal Area	Cubic Vol., dbh ≥ 1"	
					All	dbh ≥1"		o.b.	i.b.
Bedded[3]	4	2.5	1.4	7.8	755	550	5.9	43.5	22.0
"	7	2.5	2.7	19.9	730	720	29.8	370.0	229.0
Change	3	-	1.3	12.1	-25	170	23.9	326.5	207.0
Not bedded[4]	4	3	1.1	6.5	890	353	2.8	20.0	10.0
" "	7	3	2.3	17.0	827	753	24.4	283.0	171.7
Change	3	-	1.2	10.5	-63	400	21.6	263.0	161.7

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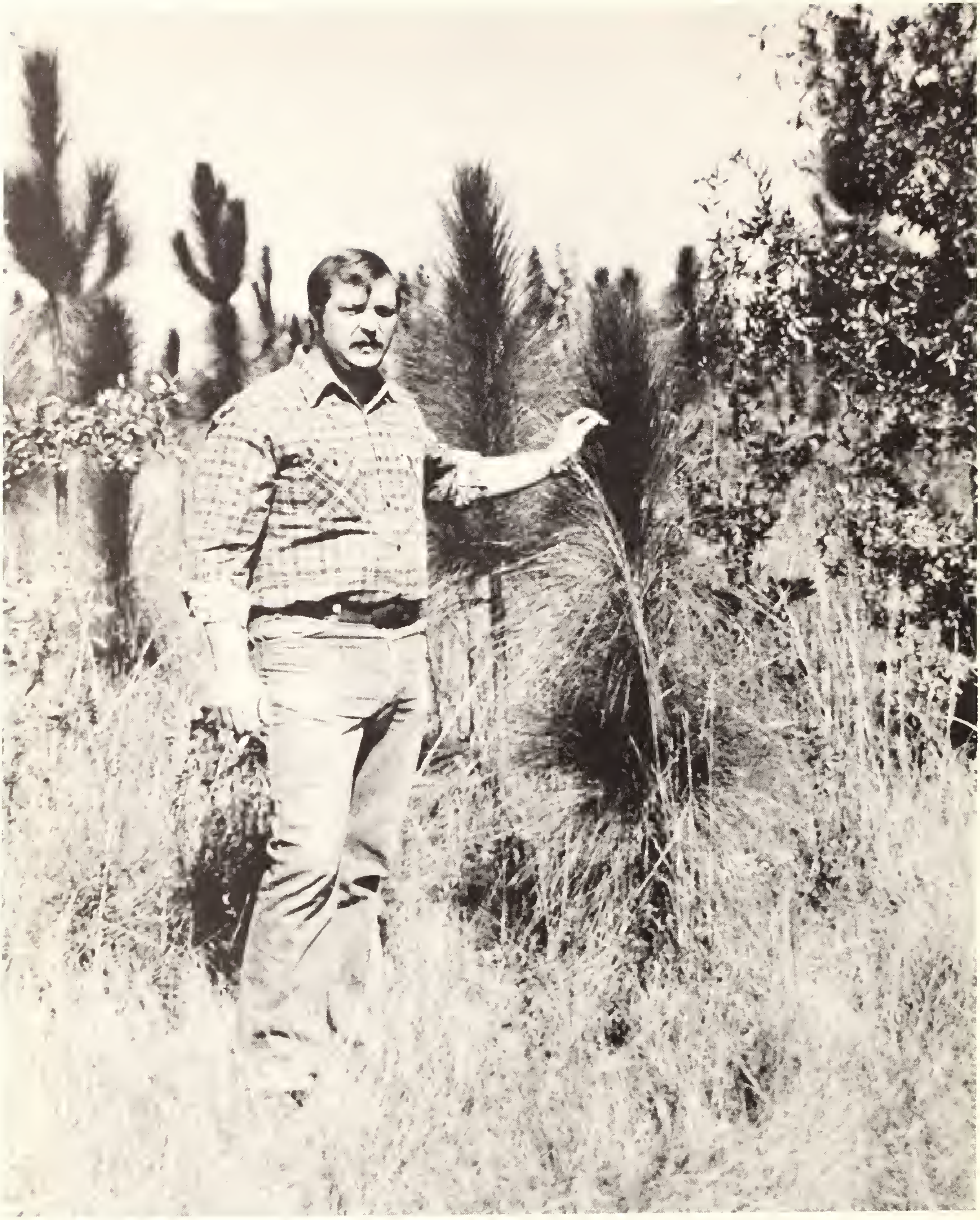
[1] Not necessarily average for plantation; plots were selected for uniform medium to low densities.

[2] Treatment comparisons are unqualified; similarity of sites before treatment is assumed but unknown.

[3] Completely prepared site plus bedding with a bedding harrow, 2 plots.

[4] " " " , no beds formed, 3 plots.



Stop 4. - Four year-old machine planted longleaf on an intensively prepared site.

STOP 5 LUNCH

STOP 6

Naturally regenerated longleaf stands

Stand 1 (West)

Size of unit: 80 acres

Age of stand: 25 years from overstory removal
31 years from seed fall

Stand height: 55-60' (dominant-codominant trees)

Stand history: Seed crop, fall 1947, seedlings established under full stand
Overstory cut winter 1948-49 to 10 residual seed trees/acre
Seed trees cut winter 1953-54, grass-stage seedling stand released

Stand 2 (East)

Size of unit: 40 acres

Age of stand: 18 years from overstory removal
21 years from seed fall

Stand height: 40-45' (dominant-codominant trees)

Stand history: Seed crop in 1947; seedlings established under full stand
Winter fire, 1950, destroys most 2-year-old seedlings
Overstory cut, winter 1951-52, to 10 seed trees/acre
Good seed crop in 1957 establishes adequate regeneration
Seed trees cut winter 1960-61, grass-stage seedling stand released

STOP 7

Season of burn and overstory density: effect on understory development

This study is testing four fire treatments (biennial burns in winter, spring, summer plus unburned check) under each of four densities (20, 30, 40, and 50 sq. ft. basal area/acre) of overstory pine. Total of 16 treatment combinations in each of two locations. All hardwoods controlled before study establishment.

Initial burns in 1970, with 5th burning cycle imposed this year. Spring and summer burns complete; winter coming up.

After 7 years, treatments have affected development of understory pine and hardwood. Number of stems per acre (more than 1.5" d.b.h.) for the 16 treatments are tabulated below.

Overstory Density (Ft.^{2} BA)	Longleaf Pine in-Growth 2" to 6" d.b.h. class					All Hardwoods 2" d.b.h. Class and Up				
	Winter : Burn :	Spring : Burn :	Summer : Burn :	No Burn	Avg.	Winter : Burn :	Spring : Burn :	Summer : Burn :	No Burn	Avg.
20	75	102	145	221	136	15	0	12	77	26
30	14	14	12	54	24	8	0	7	53	17
40	2	17	7	94	30	3	0	1	38	10
50	6	2	5	9	6	2	2	9	27	10
Average	24	34	42	94	49	7	-	7	49	16

Principal Results:

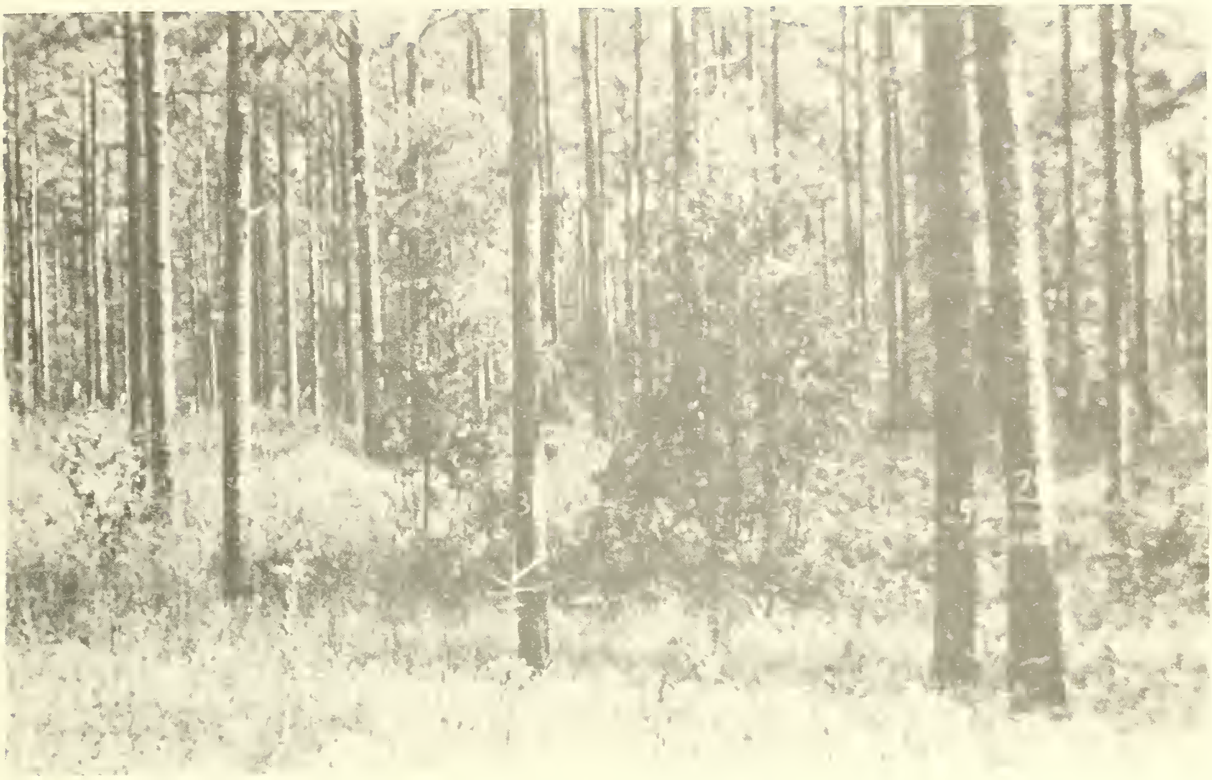
1. Season of burn does not have a great effect on longleaf seedling development which was actually somewhat better with growing season than dormant season burns.

2. Hardwood development inhibited by burning, and virtually non-existent with spring burns.

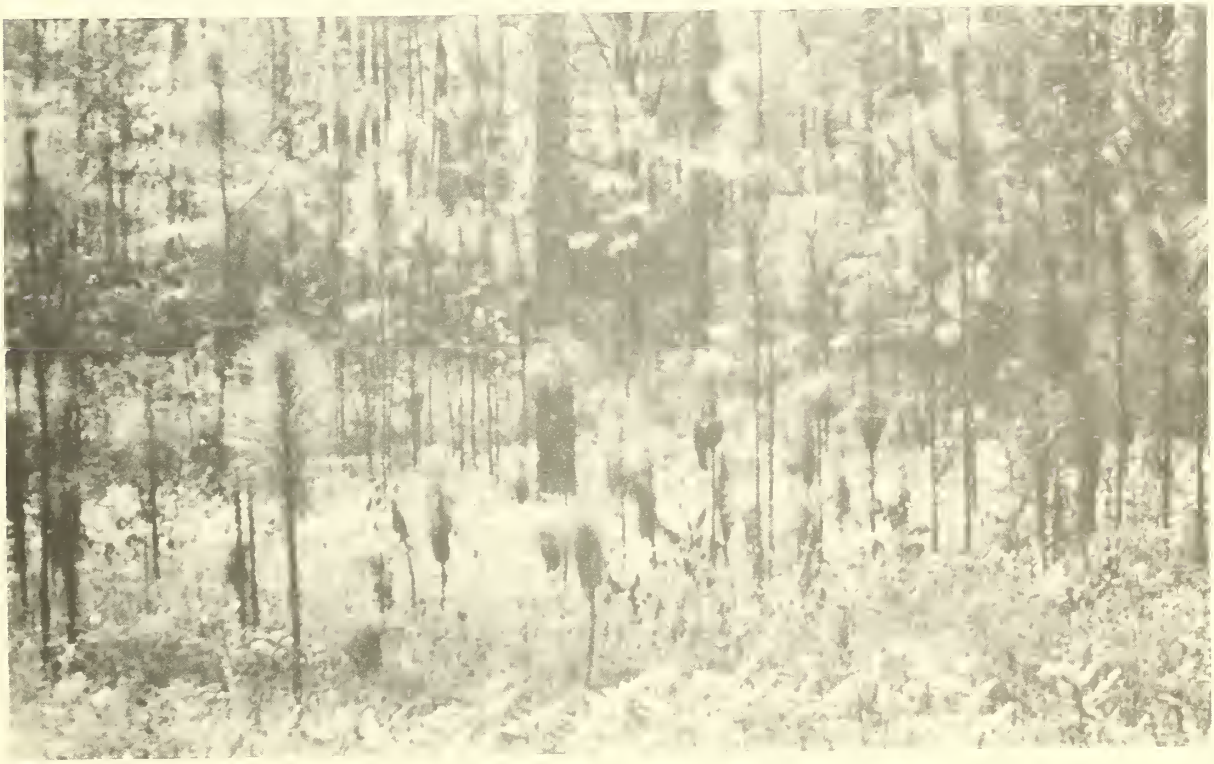
3. Development of both pine and hardwood inhibited by increasing overstory density. Longleaf pine development greatly restricted under overstory densities above 20 sq. ft., particularly when burned.

4. Appears that, under low overstory densities, periodic spring burns result in best combination of maximum development of pine regeneration with minimum hardwood encroachment.

STOP 7



Summer Burn



Winter Burn

Natural Longleaf Stand Growth and Yield Studies

Status - Some 275 permanent growth plots were installed in even-aged natural longleaf stands in the Eastern Gulf South starting in the mid-1960's. These plots were established in a broad array of stand age, site index and residual density combinations and maintained by thinning, as needed, at 5-year inventory intervals to determine tree size and stand volume growth response. Data sets from two remeasurements have been collected and the first set has been analyzed.

Principal results - The analysis has afforded a first-approximation growth and yield prediction system for thinned natural longleaf pine. Nearly any combination of age, site index, residual basal area level and low thinning schedule may be evaluated. The following table is an example of just one type of information available. Growth and yield predictors for several expressions of total and merchantable volume have been developed.

Plans - Data sets from additional remeasurements will be analyzed to see if the approximations can be improved. Attempts will be made to report future results in terms of the tree size distributions and multiple products produced.

Natural Longleaf Periodic Annual Increment (P.A.I.)*, SI = 70

Initial Age (yrs)	Residual Basal Area/Ac. @ Initial Age, sq. ft.				
	30	60	90	120	150
	Tot. Cu. Ft. Vol. P.A.I., ib., per acre				
20	95	144	179	206	228
40	63	95	116	132	143
60	46	69	85	95	101
80	36	54	66	74	78

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*P.A.I. = $(v_2 - v_1)/(A_2 - A_1)$ where v_1 = stand vol. @ initial age (A_1)
v_2 = projected stand vol. @ final age (A_2)
$A_2 = (A_1 + 5)$.

STOP 9

Southwide Pine Seed Source Study

Status - Established in 1952-53 and 1956-57 in order to determine the degree to which inherent geographic variation in longleaf is associated with climate and physiography. Seed from fourteen widely separated areas were collected and plantings of this seed established in 35 plantations containing various combinations of 6 seed sources each. The entire study was analyzed at age 10 and local data are summarized through age 15. The current age of the local plantation is 22 years.

Principal results - Overall, age 10: Central Gulf coast sources grew faster than other sources in plantings 150 miles N. and 250 & 300 miles E. & W. of origin. Farther N. & W., trees of local origin performed as well as or better than those from the Central Gulf Coast.

Local at age 15: The following table presents the performance of the local plantation (Series 4 & 5) to age 15.

Source (County)	DBH (in)	HT (ft)	T.P.A.	M.A.I. (cords)
(Series 4 - Longitude)				
Treutlen, Ga.	4.6	40	926	1.4
Baldwin, Ala.	5.1	45	883	1.8
Perry, Ala.	5.0	40	778	1.4
Washington, La.	4.6	37	710	0.9
Rapides, La.	4.5	38	932	1.2
Polk, Tex.	4.5	37	883	1.1
(Series 5 - Soils)				
Bladen, N.C.	4.6	36	908	1.2
Richmond, N.C.	4.2	34	1000	0.9
Florence, S.C.	4.6	35	673	0.8
Chesterfield, S.C.	4.6	37	914	1.2
Baldwin, Ala.	4.8	40	673	1.1
Okaloosa, Fla.	5.0	39	549	0.9

The Baldwin county source had 6% larger d.b.h., 10% taller height and 24% more volume than the average for the plantation.

The plantation was thinned at age 15, reducing stand density from 820 TPA to 510 TPA. Average volumes per acre were: 21.5 cords, before cut; 17.3 cords, left; and 4.2 cords, removed. The M.A.I. to age 15 was 1.4 cords/ac./yr. and P.A.I. from age 10 to 15 was 2.9 cords/ac/yr.

Plans - The study continues. The data from all the SPSSS plantations have been included in a data pool under analysis which consists of some 3000 plot observations on unthinned longleaf plantation yields. Plans are to present stand and stock table yields for old-field, prepared forest and cutover forest sites.

FORESTRY SCIENCES LABORATORY AND FIELD TRIP SUMMARY

by Calvin Bey 1/

At the Forestry Sciences Laboratory, Southern Forest Experiment Station, Gulfport, Mississippi, two projects are concerned with research of longleaf pine. Calvin Bey is project leader for the Genetics of Southern Pines Project and Glenn Snow is the project leader for Diseases of Southern Pine Project. In the projects, Bayne Snyder works primarily on longleaf genetics while Al Kais works on pathology problems. The projects work cooperatively on many studies.

In the greenhouse, scientists have research dealing with early selection of longleaf for brown-spot needle blight resistance. Spray techniques for early inoculation have been developed. Tests are under way to look for variation in the pathogen and in the longleaf resistance. The greenhouse results are being compared with tests in the field.

A technique has been developed at the Harrison for field screening (progeny testing) for brown-spot resistance that works very well. Planting sites are selected in areas where natural longleaf seedlings are abundant and there is a good source of brown-spot inoculum. Narrow strips are disced at 10-foot intervals to provide a good planting site. Trees are planted in the strips at 3-foot spacings. Areas around the trees are kept weed free to allow good rain splash and spread of any brown-spot spores from the adjacent natural seedlings. Resistant seedlings can be easily identified and, if so desired, the susceptibles can be rogued, thereby giving an orchard of improved material. These orchards can then be used for further breeding and selection. Results from older orchards show that crosses among the elite will yield large genetic gains for growth.

One longleaf breeding experiment at the Harrison involves intercrossing 13 random parents and outplanting the progeny at two locations. This study demonstrates again the problems associated with self-pollinated progenies. Survival and growth were very poor for selfs when compared to wind or controlled crosses. One surprising result of this study has been the complete lack of maternal and reciprocal effects. This is a welcome surprise. In our future breeding work, half diallels will be used in place of full diallels. This test also verified that short-term progeny tests are valid and that wind-pollinated tests are efficient for genetic evaluation of individual parent trees.

Research is under way on the use of Benlate as a seedling root-dip treatment and mycorrhizae (Pisolithus tinctorius (Pers.) Cok. & Couch) to control brown spot on longleaf pine in the field. After 2 years, various combinations of the treatments look encouraging. In cooperation with S&PF, a region-wide test is under way to test the effectiveness of Benlate root-dip treatment for disease control.

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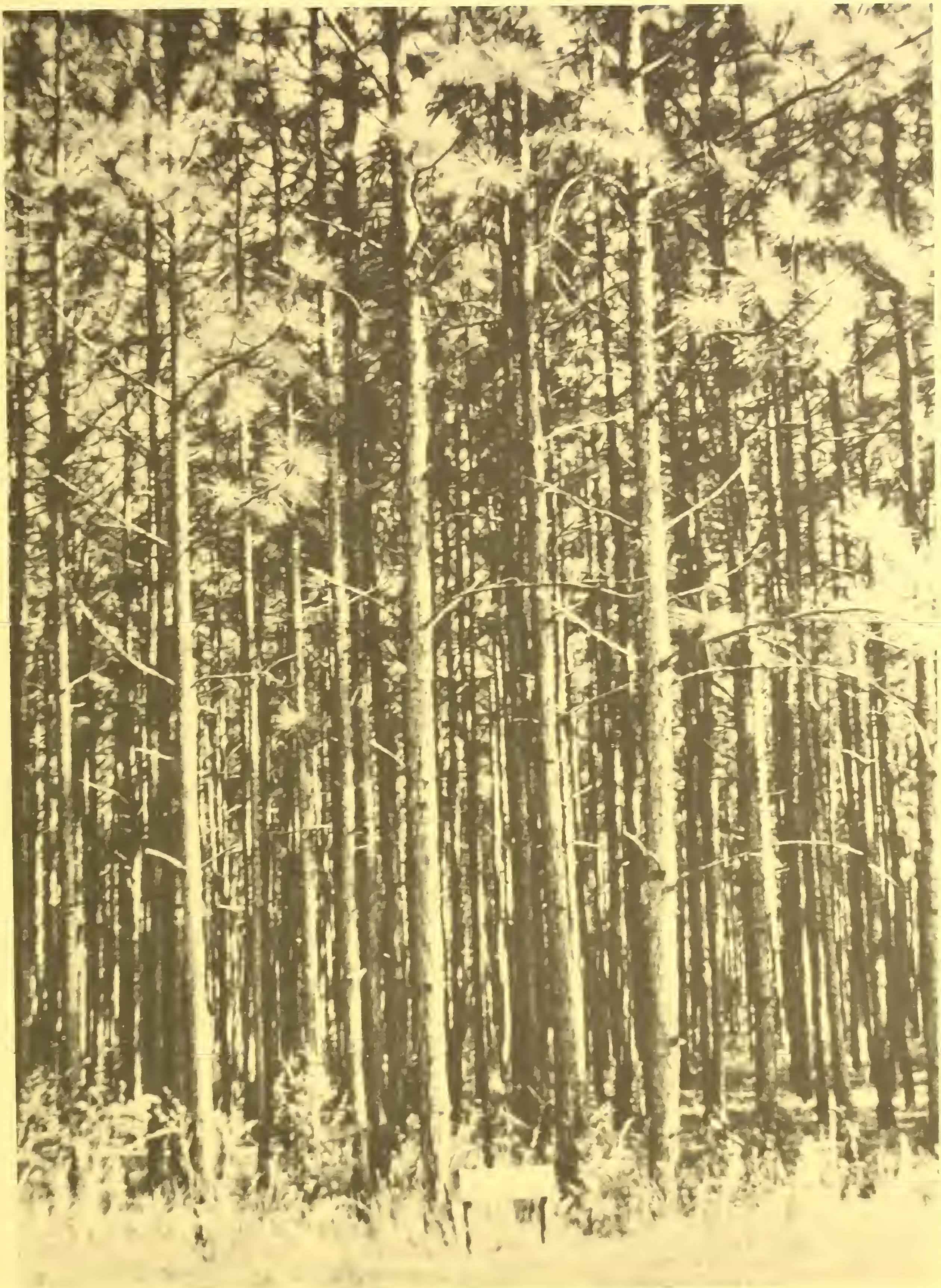

22 year-old seed source study -- Rapides Parish, La.
seed source -- Escambia Experimental Forest

Field trip photos courtesy of Don Van Houten, Alabama Forestry Commission

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